Program and Abstracts

Flatfish Biology Conference

December 1-2, 1998
Mystic, Connecticut

Sponsored by

National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Northeast Fisheries Science Center
Woods Hole, Massachusetts

Northeast Fisheries Science Center Reference Documents

This series is a secondary scientific series designed to assure the long-term documentation and to enable the timely transmission of research results by Center and/or non-Center researchers, where such results bear upon the research mission of the Center (see the outside back cover for the mission statement). These documents receive internal scientific review, and most receive copy editing. The National Marine Fisheries Service does not endorse any proprietary material, process, or product mentioned in these documents.

All documents issued in this series since April 2001, and several documents issued prior to that date, have been copublished in both paper and electronic versions. To access the electronic version of a document in this series, go to *http://www.nefsc.noaa.gov/nefsc/publications/*. The electronic version is available in PDF format to permit printing of a paper copy directly from the Internet. If you do not have Internet access, or if a desired document is one of the pre-April 2001 documents available only in the paper version, you can obtain a paper copy by contacting the senior Center author of the desired document. Refer to the title page of the document for the senior Center author's name and mailing address. If there is no Center author, or if there is corporate (*i.e.*, non-individualized) authorship, then contact the Center's Woods Hole Laboratory Library (166 Water St., Woods Hole, MA 02543-1026).

This document's publication history is as follows: manuscript submitted for review January 15, 2008; manuscript accepted through technical review February 6, 2008; manuscript accepted through policy review February 7, 2008; and final copy submitted for publication February 7, 2008. Pursuant to section 515 of Public Law 106-554 (the Information Quality Act), this information product has undergone a pre-dissemination review by the Northeast Fisheries Science Center, completed on February 6, 2008. The signed pre-dissemination review and documentation is on file at the NEFSC Editorial Office. This document may be cited as:

Calabrese A (chair), Beck A, Burnett J, Danila D, Howe A, Howell P, Jearld A, Powell C, Studholme A. 2008. Flatfish Biology Workshop, December 1-2, 1998, Mystic, Connecticut. US Dept Commer, Northeast Fish Sci Cent Ref Doc. 08-05f; 68 p. Available from: National Marine Fisheries Service, 166 Water Street, Woods Hole, MA 02543-1026.

Northeast Fisheries Science Center Reference Document 08-05f

Flatfish Biology Workshop
December 1-2, 1998, Mystic, Connecticut

by Conference Steering Committee: Anthony Calabrese (Chair)[1],
Allan Beck[2], Jay Burnett[3], Donald Danila[4], Arnold Howe[5],
Penelope Howell[6], Ambrose Jearld[3], Chris Powell[7], and Anne Studholme[8]

[1] National Marine Fisheries Service, Milford CT 06460-6490
[2] Environmental Advantage Group, Prudence Island RI 02872
[3] National Marine Fisheries Service, Woods Hole MA 02543
[4] Northeast Utilities Environmental Laboratory, Waterford CT 06385
[5] Massachusetts Division of Marine Fisheries, Sandwich MA 02563
[6] Connecticut Department of Marine Environmental Protection, Old Lyme CT 06385
[7] Rhode Island Division of Fish and Wildlife, Wickford RI 02852
[8] National Marine Fisheries Service, Highlands NJ 07732

Sixth in a series of Flatfish Biology Conferences

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Northeast Fisheries Science Center
Woods Hole, Massachusetts

February 2008

Cover Design

Diane Rusanowsky
National Marine Fisheries Service
Milford, CT

Sponsored by

National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Northeast Fisheries Science Center
Woods Hole, MA

Flatfish Biology Workshop

December 1-2, 1998, Best Western Sovereign Hotel, Mystic, Connecticut

Oral Presentations

Tuesday, December 1st

7:30 a.m. **Registration/Coffee, Danish and Muffins**

8:15 a.m. Welcome and Introduction
Anthony Calabrese, Chair
National Marine Fisheries Service
Milford Laboratory
Milford, CT

Michael Sissenwine, Director
National Marine Fisheries Service
Northeast Fisheries Science Center
Woods Hole, MA

Session I

Penny Howell, Chair
Connecticut Department of Environmental Protection
Fisheries Division, Old Lyme, CT

8:30 a.m. Comparison of Flatfish Species Abundances and Distributions (1970's versus 1990's) in the Thames River (CT) Estuary
D. Tolderlund and D. Orchard
U. S. Coast Guard Academy, Department of Science, New London, CT

8:50 a.m. Growth and Mortality Rates of Young-of-the-Year Winter Flounder in Narragansett Bay: Length-based Model Revisited
A. DeLong[1], J. Collie[1], C. Meise[2], and C. Powell[3]
[1]University of Rhode Island, Graduate School of Oceanography, Narragansett, RI, [2]National Marine Fisheries Service, James J. Howard Marine Science Laboratory, Highlands, NJ, and [3]Rhode Island Department of Environmental Management, Division of Fish and Wildlife, Wickford, RI

9:10 a.m. Evidence of Tidal Period Migration for Winter Flounder, *Pseudopleuronectes americanus*, in a Southern New Jersey Estuary
M. C. Curran[1], R. Chant[2], K. Able[3], and S. Glenn[2]
[1]University of South Carolina, Beaufort, SC, [2]Rutgers University, Institute of Marine and Coastal Studies, New Brunswick, NJ, and [3]Rutgers University, Marine Field Station, Tuckerton, NJ

9:30 a.m. Estimating the Abundance of Winter Flounder Spawning in the Niantic River, CT
D. Danila
Northeast Utilities Environmental Laboratory, Waterford, CT

9:50 a.m. Apparent Compensatory Mechanisms During the Egg and Larval Stages of Winter Flounder
J. D. Miller
Northeast Utilities Environmental Laboratory, Waterford, CT

10:10 a.m. **Coffee/Danish/Muffins**

Session II

Don Danila, Chair
Northeast Utilities Environmental Laboratory
Waterford, CT

10:30 a.m. The Role of Intra- and Inter-individual Variability on Consumption Rates of Recently Metamorphosed Winter Flounder, *Pseudopleuronectes americanus*
M. Walsh, D. Witting, and C. Chambers
National Marine Fisheries Service, James J. Howard Marine Sciences Laboratory, Highlands, NJ

10:50 a.m. Morphological Transitions During the Early Ontogeny of Windowpane, *Scophthalmus aquosus*
M. Neuman and K. Able
Rutgers University, Marine Field Station, Tuckerton, NJ

11:10 a.m. Dermatitis of Juvenile Summer Flounder
R. Smolowitz[1], E. Baker[2], and R. Bullis[1]
[1]Marine Biological Laboratory, Laboratory for Aquatic Animal Medicine and Pathology, Woods Hole, MA and [2]PVC Corporation, Fall River, MA

11:30 a.m. Assessment of Young-of-the-Year Winter Flounder Habitat using RNA as an Index of Condition
C. Kuropat[1], R. Mercaldo-Allen[1], R. Goldberg[1], F. Thurberg[1], and B. Phelan[2]
[1]National Marine Fisheries Service, Milford Laboratory, Milford, CT, and [2]National Marine Fisheries Service, James J. Howard Marine Sciences Laboratory, Highlands, NJ

11:50 a.m. Glycine Stimulates Winter Flounder Renal Tubule Organic Anion Secretion
L. Renfro[1,2], D. Miller[1,3], M. Dawson[2], S. Lechter[1], S. Fujukawal[1], and B. Toomey[1,3]
[1]Mount Desert Island Biological Laboratory, Salsbury Cove, ME, [2]University of Connecticut, Department of Physiology and Neurobiology, Storrs, CT, and [3]NIH-NIEHS Laboratory of Pharmacology and Chemistry, Research Triangle Park, NC

12:10 p.m. **Hosted Buffet Lunch**

Session III

Ambrose Jearld, Chair
National Marine Fisheries Service
Woods Hole, MA

1:10 p.m. Size-specific Predation on Juvenile Summer Flounder, *Paralichthys dentatus*, and the Duration of the Window of Vulnerability
S. Barbeau[1], C. Chambers[2], D. Witting[2], and K. Able[3]
[1]Rutgers University, Graduate Program in Ecology and Evolution, New Brunswick, NJ, [2]National Marine Fisheries Service, James J. Howard Marine Sciences Laboratory, Highlands, NJ, and [3]Rutgers University, Marine Field Station, Tuckerton, NJ

1:30 p.m. A Microbiological Survey of Larval Summer Flounder and their Culture Environment at a Commercial Aquaculture Facility

S. Eddy[1], S. Jones[1], G. Nardi[2], and B. Summer-Brason[1]
[1]University of New Hampshire, Jackson Estuarine Laboratory, Durham, NH, and [2]Great Bay Aquafarms, Portsmouth, NH

1:50 p.m. How do Witch Flounder Cope with an Extended Larval Period?

J. Rabe and J. Brown
Memorial University of Newfoundland, Ocean Sciences Centre, St. John's, Newfoundland, Canada

2:10 p.m. Dietary Variation in Age-0 Winter Flounder in a New Jersey Estuary

L. Stehlik and C. Meise
National Marine Fisheries Service, James J. Howard Marine Sciences Laboratory, Highlands, NJ

2:30 p.m. Species-specific Predation on Natural Zooplankton by Newly-settled Winter Flounder, *Pseudopleuronectes americanus*

P. Shaheen[1], L. Stehlik[2], and J. Manderson[2]
[1]Rutgers University, Institute of Marine and Coastal Sciences, New Brunswick, NJ, and [2]National Marine Fisheries Service, James J. Howard Marine Sciences Laboratory, Highlands, NJ

2:50 p.m. **Refreshment Break**

Session IV

Anne Studholme, Chair
National Marine Fisheries Service
Highlands, NJ

3:10 p.m. Field and Laboratory Observations on Spawning, Feeding, and Locomotion in Winter Flounder

A. Stoner, A. Bejda, J. Manderson, B. Phelan, L. Stehlik, and J. Pessutti
National Marine Fisheries Service, James J. Howard Marine Sciences Laboratory, Highlands, NJ

3:30 p.m. Variation in Reproductive Output of Mid-Atlantic Bight Flatfishes

P. Berrien and C. Chambers
National Marine Fisheries Service, James J. Howard Marine Sciences Laboratory, Highlands, NJ

3:50 p.m. How Important is the Green Crab, *Carcinus maenas*, as a Predator of YOY Winter Flounder, *Pseudopleuronectes americanus*?

E. Fairchild and W. H. Howell
University of New Hampshire, Coastal Marine Laboratory, Durham, NH

4:10 p.m. Substratum Preference by Young-of-the-Year Winter Flounder, *Pseudopleuronectes americanus,* and the Influence of Food

B. Phelan and J. Manderson
National Marine Fisheries Service, James J. Howard Marine Sciences Laboratory, Highlands, NJ

4:30 p.m. Predation by Striped Searobin, *Prionotis evolans*, on Age-0 Winter Flounder, *Pseudopleuronectes americanus,* and an Alternative Benthic Invertebrate Prey, *Crangon septemspinosa*

J. Manderson[1], B. Phelan[1], L. Stehlik[1], A. Bejda[1], and M. Nunez[2]
[1]National Marine Fisheries Service, James J. Howard Marine Sciences Laboratory, Highlands, NJ, and [2]Rutgers University, Institute of Coastal and Marine Sciences, New Brunswick, NJ

4:50 p.m. **Poster set-up**

6:00 p.m. **Hosted Mixer and Poster Session**

Wednesday, December 2nd

7:45 a.m. **Registration/Coffee, Danish and Muffins**

Session V

Chris Powell, Chair
Rhode Island Division of Environmental Management
Wickford, RI

8:10 a.m. Using Winter Flounder Growth Rates to Assess Habitat Quality Across an Anthropogenic Gradient in Narragansett Bay, RI
C. Powell[1] and L. Meng[2]
[1]Rhode Island Division of Environmental Management, Fish and Wildlife, Wickford, RI, and [2]U. S. Environmental Protection Agency, Atlantic Ecology Division, Narragansett, RI

8:30 a.m. Comparative Survival and Behavior of Hatchery-reared versus Wild Summer Flounder: A Laboratory Approach
T. Kellison
North Carolina State University, Department of Marine, Earth, and Atmospheric Sciences, Raleigh, NC

8:50 a.m. Habitat Utilization of Juvenile Summer Flounder in the Virginia Portion of the Chesapeake Bay
R. Kraus and J. Musick
Virginia Institute of Marine Science, School of Marine Science, Gloucester Point, VA

9:10 a.m. Comparison of Models for Defining Nearshore Flatfish Nursery Areas of Flatfishes in Alaskan Waters
B. Norcross, A. Blanchard, and B. Holladay
University of Alaska Fairbanks, Institute of Marine Science, Fairbanks, AK

9: 30 a.m. Habitat-specific Utilization of Nursery Grounds in Juvenile Summer Flounder, *Paralichthys dentatus*: A Mark-recapture Experiment
J. C. Taylor
North Carolina State University, Department of Zoology, Raleigh, NC

9:50 a.m. A Long-term Study of Settlement and Growth Patterns in Young-of-the-Year Winter Flounder in New Jersey Estuaries
S. Sogard[1] and K. Able[2]
[1]National Marine Fisheries Service, Hatfield Marine Science Center, Newport, OR, and [2]Rutgers University, Marine Field Station, Tuckerton, NJ

10:10 a.m. **Coffee/Danish/Muffins**

Session VI

Jay Burnett, Chair
National Marine Fisheries Service
Woods Hole, MA

10:30 a.m. Quantifying Ontogenetic Change: A Multivariate Analysis of Larval Development in Flatfishes
H. Hamlin, C. Chambers, and D. Witting
National Marine Fisheries Service, James J. Howard Marine Sciences Laboratory, Highlands, NJ

10:50 a.m. Effects of Pier Shading on the Growth of Juvenile Winter Flounder, *Pseudopleuronectes americanus*
J. Duffy-Anderson and K. Able
Rutgers University, Marine Field Station, Tuckerton, NJ

11:10 a.m. The Interaction of Turbidity and Substrate Preferenda of Winter Flounder, *Pseudopleuronectes americanus*
P. Grecay and K. Stierhoff
Salisbury State University, Department of Biological Sciences, Salisbury, MD

11:30 a.m. Revisions in Flatfish Taxonomy: Sometimes the Names Have to Change
J. A. Cooper
National Marine Fisheries Service, Systematics Laboratory, Museum of Natural History, Washington, DC

11:50 a.m. Using Coded Wire Tags to Study Movement and Growth of Young-of-the-Year Winter Flounder, *Pseudoleuronectes americanus*, in Point Judith Pond, Rhode Island
R. Young-Morse and C. Recksiek
University of Rhode Island, Department of Fisheries, Animal, and Veterinary Science, Kingston, RI

12:10 p.m. **Hosted Buffet Lunch**

Session VII

Arnold Howe, Chair
Massachusetts Division of Marine Fisheries
Pocasset, MA

1:10 p.m. The Foraging Ecology of Yellowtail Flounder, *Limanda ferruginea*, Larvae: Inferences from Laboratory Studies
J. Brown and V. Puvanendran
Memorial University of Newfoundland, Ocean Sciences Centre, St. John's, Newfoundland, Canada

1:30 p.m. The Effects of Temperature and Salinity on Feeding, Growth, and Survival of Juvenile Summer and Southern Flounder, with a Comparison of Salinity Preference
U. Howson and T. Targett
University of Delaware, Graduate School of Marine Studies, Lewes, DE

1:50 p.m. Benefits of Green Water: Effects on Growth, Survival and Time to Metamorphosis of Winter Flounder, *Pseudopleuronectes americanus*

D. Bidwell and W. H. Howell
University of New Hampshire, Coastal Marine Laboratory, New Castle, NH

2:10 p.m. The Effects of Feeding Schedule and Frequency of Feeding on Summer Flounder Juvenile Growth in Recirculating Systems

G. Klein-MacPhee[1], B. Murphy[2], and E. Rectisky[2]
[1]*University of Rhode Island, Graduate School of Oceanography, Narragansett, RI, and*
[2]*University of Rhode Island, Department of Fisheries, Animal and Veterinary Science, Kingston, RI*

2:30 p.m. Variation in Temperature Effects on Embryonic and Early Larval Period Attributes of Winter Flounder, *Pseudopleuronectes americanus*

C. Chambers
National Marine Fisheries Service, James J. Howard Marine Sciences Laboratory, Highlands, NJ

2:50 p.m. **Refreshment Break**

Session VIII

Allan Beck
Environmental Advantage Group
Prudence Island, RI

3:10 p.m. The Basis and Potential Utility of Meristic and Morphological Variation in Winter Flounder, *Pseudopleuronectes americanus*

D. Witting and C. Chambers
National Marine Fisheries Service, James J. Howard Marine Sciences Laboratory, Highlands, NJ

3:30 p.m. Survival of Larval Winter Flounder, *Pseudopleuronectes americanus:* Evidence for a Critical Period?

S. Lewis, C. Chambers, and D. Witting
National Marine Fisheries Service, James J. Howard Marine Sciences Laboratory, Highlands, NJ

3:50 p.m. Effect of Dietary Protein Level on the Growth, Survival, and Feed Performance of Juvenile Summer Flounder, *Paralichthys dentatus*

N. King and W. H. Howell
University of New Hampshire, Department of Zoology, Durham, NH

4:10 p.m. Larval Rearing Techniques of Yellowtail Flounder

V. Puvanendran, D. Boyce, N. Morris, and J. Brown
Memorial University of Newfoundland, Ocean Sciences Centre, St. John's, Newfoundland, Canada

Poster Session
Tuesday, December 1st, 6:00 p.m.

Post-metamorphic Growth of Summer Flounder in Laboratory Culture: Do Early-settling Larvae Grow Faster than Late Settlers?
T. Simlick, R. Katersky, N. Marcaccio, and D. Bengtson
University of Rhode Island, Department of Fisheries, Animal and Veterinary Science, Kingston, RI

Effect of Photoperiod on Survival, Growth and Pigmentation of Summer Flounder, *Paralichthys dentatus*, Larvae in Laboratory Culture
M. Huber, E. Moore, N. Maraccio, R. Katersky, and D. Bengston
University of Rhode Island, Department of Fisheries, Animal and Veterinary Science, Kingston, RI

Otogenetic Diet Shifts of Larval and Juvenile Flatfish: Estimating Turnover Rates with Stable-Isotope Ratios
K. Bosley[1], D. Witting[2], C. Chambers[2], and S. Wainright[1]
[1]Rutgers University, Institute of Marine and Coastal Science, New Brunswick, NJ, and [2]National Marine Fisheries Service, James J. Howard Marine Sciences Laboratory, Highlands, NJ

Molecular Characterization of Ribosomal DNA from Representative Flatfishes of the U.S. Atlantic Coast
P. Kar[1], Z. M. G. Sarwar. Jahangir[2], and R. Eckhardt[1]
[1]Brooklyn College of CUNY, Brooklyn, NY, and [2]The Richard Stockton College of New Jersey, Pomona, NJ

Size-specific Predation on Recently Metamorphosed Winter Flounder, *Pseudopleuronectes americanus*, and the Duration of Their Vulnerability to *Crangon septemspinosa*
D. Witting and C. Chambers
National Marine Fisheries Service, James J. Howard Marine Sciences Laboratory, Highlands, NJ

Temperature Effects on Age, Size and Condition at Hatching in Windowpane, *Scophthalmus aquosus*
M. Cook and C. Chambers
National Marine Fisheries Service, James J. Howard Marine Sciences Laboratory, Highlands, NJ

The Distribution and Size Composition of Five Flatfish Species in Long Island Sound Based on the Connecticut Fisheries Division Bottom-trawl Survey, 1984-1997
K. Gottschall, M. Johnson, and D. Simpson
Connecticut DEP, Fisheries Division, Old Lyme, CT

Aspects of the Life History of Hogchoker, *Trinectes maculatus*, in Delaware Bay Marsh Creeks
R. Bush and K. Able
Rutgers University Marine Field Station, Tuckerton, NJ

Growth of Young-of-the-Year Winter Flounder, *Pseudopleuronectes americanus*, within Eelgrass, *Zostera marina*: Impact of Habitat Edge
P. Bologna and K. Able
Rutgers University Marine Field Station, Tuckerton, NJ

An Evaluation of the Relationship between Otolith Microstructure, Otolith Growth, and Somatic Growth in a Temperate Flatfish, *Scophthalmus aquosus*
M. Newman[1], D. Witting[2], and K. Able[1]
[1]Rutgers University Marine Field Station, New Brunswick, NJ, and *[2]National Marine Fisheries Service, James J. Howard Marine Sciences Laboratory, Highlands, NJ*

Development of Spawning and Rearing Techniques for Southern Flounder in South Carolina
M. Denson and T. Smith
Marine Resources Research Institute, South Carolina Department of Natural Resources, Charleston, SC

Comparison of Diets Among Four Co-occurring Juvenile Flatfishes near Kodiak Island, Alaska
B. Holladay
University of Alaska Fairbanks, Institute of Marine Science, School of Fisheries and Ocean Sciences, Fairbanks, AK

Somatic Growth and Otolith Growth in Juvenile Fringed Flounder *Etropus crossotus*
M. Reichert[1], J. Dean[1], R. Feller[1], and J. Grego[2]
[1]University of South Carolina, Belle W Baruch Institute, Columbia, SC, and [2]University of South Carolina, Department of Statistics, Columbia, SC

Utilization of Intertidal and Marina Habitats by Juvenile Winter Flounder, *Pseudopleuronectes americanus*
M. Mroczka[1], J. Carlson[2], T. Randall[3], and P. Pellegrino[4]
[1]Cedar Island Marina Research Laboratory, Clinton, CT, [2]National Marine Fisheries Service, Panama City, FL, [3]University of Mississippi, Department of Biology, University, MS, and [4]Southern Connecticut State University, Department of Biology, New Haven, CT

Winter Flounder Tagging in Western Cape Cod Bay in the Decade of the 1990s: Movements, Fidelity, and Population Size
R. Lawton, B. Kelly, J. Boardman, and V. Malkoski
Massachusetts Division of Marine Fisheries, Pocasset, MA

Effects of 2, 3, 7, 8- Tetrachloroolibenzo-p-Dioxin on Winter Flounder Embryos from NY/NJ Harbor Estuary and Long Island Sound
K. Cooper
Rutgers University, Department of Biochemistry and Microbiology, New Brunswick, NJ

Abstracts
Oral Presentations

Comparison of Flatfish Species Abundances and Distributions (1970s versus 1990s) in the Thames River (CT) Estuary

Douglas S. Tolderlund and Daniel R. Orchard

U. S. Coast Guard Academy
Department of Science
27 Mohegan Avenue
New London, CT 06320

Bottom trawl and beach seine samples were taken during 1972-1974 and 1992-1998 on the Thames River (CT) adjacent to the U. S. Coast Guard Academy (river mile 4). The three habitats studied in the estuary included a channel dredged to 41 ft (sta. 60), a 10-ft shoal site (sta. 65), and a sandy beach at Jacob's Rock (JR). Principal flatfish observed include winter flounder (*Pseudopleuronectes americanus*), summer flounder (*Paralichthys dentatus*), windowpane (*Scophthalmus aquosus*), fourspot flounder (*Paralichthys oblongus*), and hogchocker (*Trinectes maculatus*). Our study focused on a comparison of the flatfish population distributions in terms of species and size as related to habitat, season, and year.

Growth and Mortality Rates of Young-of-the-Year Winter Flounder in Narragansett Bay: Length-based Model Revisited

Allison Delong[1], Jeremy Collie[1], Carol Meise[2], and Chris Powell[3]

[1]*University of Rhode Island*
Graduate School of Oceanography
South Ferry Road, Narragansett, RI 02882

[2]*National Marine Fisheries Service*
James J. Howard Marine Sciences Laboratory
74 Magruder Road, Highlands, NJ 07732

[3]*Rhode Island Department of Environmental Management*
Division of Fish and Wildlife
150 Fowler Street, Wickford, RI 02852

Much attention has focused on determining recruitment of juvenile finfish into the exploitable adult population. To this end, many experiments have attempted to quantify young-of-the-year (YOY) fish abundance and mortality. Most estimates of mortality come from linearized catch curves fit with least squares regressions, which assume that the population is closed and mortality is constant over the time period of interest. Although numerous factors may influence YOY mortality, it is believed that mortality rates and growth rates may decrease as fish size increases. This results in changes in mortality rates throughout the first year of life as the individuals in the population grow. A length-based model has been constructed which quantifies the changes in growth and mortality rates of YOY winter flounder. We used a modified version of this model to quantify growth and mortality rates of YOY winter flounder using 1988 to 1998 CPUE estimates from the Rhode Island Division of Fish and Wildlife beach seine survey in Narragansett Bay. We attempt to explain year-to-year variability in these estimates by considering both temperature and density-dependent growth and mortality.

Evidence of Tidal Period Migration for Winter Flounder, *Pseudopleuronectes americanus*, in a Southern New Jersey Estuary

Mary Carla Curran[1], Robert J. Chant[2], Kenneth W. Able[3], and Scott M. Glenn[2]

[1]University of South Carolina
801 Carteret St., Beaufort, SC 29902

[2]Rutgers University
Institute of Marine and Coastal Studies
New Brunswick, NJ 08903

[3]Rutgers University, Marine Field Station
Tuckerton, NJ 08087

Our prior research has indicated that coves near Little Egg Harbor Inlet, NJ are settlement areas for winter flounder, *Pseudopleuronectes americanus*, and that estuarine circulation patterns in this well-mixed, flood-dominated system support the advection of larvae into these coves. In 1997, we performed both surface and bottom plankton tows synchronously with repeated Acoustic Doppler Current Profiler (ADCP) transects over the study area. Results indicate that a flow separation (tidally driven eddy) near the inlet traps estuarine water during flooding current and that coves tend to be filled with this water. Therefore, larvae hatched in the estuarine spawning ground are transported toward the inlet during the ebb, but during the flood these larvae are trapped by the flow separation and are advected into the cove. However despite tidal currents approaching 2 m/s, our observations indicate that the temporal variability of larval abundances cannot be explained solely by horizontal advection from an estuarine source. In fact, the larval abundances are highest during the flood when salinities indicate waters are of an offshore origin. Three possibilities are discussed to explain this temporal variability; 1) an offshore source of winter flounder larvae, 2) enhanced vertical mixing during the stronger flood tide, or 3) tidal period vertical migration. An offshore source is discounted based on what is currently known about winter flounder spawning. Results from numerical simulations indicate that ebb to flood asymmetries in vertical mixing, though present, cannot explain the enhanced larval abundance during flooding current. Subsequently we conclude that enhanced larval abundances during the flood is evidence of tidally-influenced vertical migration. Larvae that migrate to the bottom of the channel during the ebb may avoid being swept out the inlet and instead may rise to the surface during the subsequent flood to find suitable settlement habitat, in this instance within coves, in the estuary.

Estimating the Abundance of Winter Flounder Spawning in the Niantic River, CT

Donald J. Danila

Northeast Utilities Environmental Laboratory
PO Box 128, Waterford, CT 06385

The winter flounder is a coastal flatfish most abundant in the central portion of its range, including Long Island Sound. Its population is subdivided into a number of stocks associated with specific estuaries or coastal areas, and adults tend to faithfully return to natal estuaries to spawn each winter. Northeast Utilities has monitored the abundance of adult winter flounder spawning in the Niantic River, CT embayment during mid-February to early April of each year since 1976. Winter flounder are captured using a 9.1-m otter trawl and all fish larger than 20 cm are marked with a brand chilled in liquid nitrogen before returning them to the river. Annually, relative abundance is characterized by trawl catch-per-unit-effort (CPUE) and absolute abundance estimates have been generated since 1984 using the mark and recapture data and the Jolly model for open populations. Information on sex ratio, length-frequency distribution, and spawning condition is also recorded during each survey. Using a length-fecundity relationship, annual egg production estimates have also been calculated.

Although the two abundance estimates are independent of one another, CPUE and absolute abundance estimates are highly correlated. Abundance of Niantic River winter flounder peaked in the early 1980s; but as fishing mortality increased to high levels in the late 1980's, abundance declined thereafter and presently is very low. Despite small numbers of spawners at present, adult winter flounder remain capable of producing large numbers of larvae, which under appropriate conditions can result in a relatively strong year-class of juveniles.

Apparent Compensatory Mechanisms during the Egg and Larval Stages of Winter Flounder

J. Dale Miller

Northeast Utilities Environmental Laboratory
PO Box 128, Waterford, CT 06385

The Niantic River winter flounder spawning stock has been declining since the mid-1980s based on annual population estimates from mark and recapture studies conducted during their spawning season, primarily February through early April. In addition, larval winter flounder abundance, growth and mortality were monitored from February through early June 1994. As expected, total egg production in the Niantic River has decreased concurrent with the decline of spawning adults. From 1984 through 1994 the annual abundances of yolk-sac larvae were positively correlated with annual total egg production estimates, suggesting that egg survival was similar among these years. However, the abundance of newly hatched larvae from 1995 through 1997 appeared to be greater than expected from this relationship, with egg survival increasing as production declined to relatively low levels. Possibly, egg survival is a compensatory mechanism, where egg abundance less than some threshold resulted in less predation pressure, perhaps because of fewer cues for predators. In addition, annual larval mortality rates were compared to total egg production and seasonal water temperatures using a multiple regression model. The best model indicated that larval mortality decreased as egg production decreased and April water temperatures increased. This suggested that density-dependent larval mortality occurred in the Niantic River that was further moderated by April water temperatures. The effect of temperature on mortality may be due to its positive relationship to rates of larval growth and development.

The role of Intra- and Inter-individual Variability on Consumption Rates of Recently Metamorphosed Winter Flounder, *Pseudopleuronectes americanus*

Michelle Walsh, David Witting, and Christopher Chambers

National Marine Fisheries Service
James J. Howard Marine Sciences Laboratory
74 Magruder Road, Highlands, NJ 07732

The rate of prey consumption is a key component of any analysis of fish bioenergetics. We report results from an experimental investigation of variation in consumption rates of recently metamorphosed winter flounder, *Pseudopleuronectes americanus*. Our objectives were 1) estimate the variation in consumption rates among individual fish, 2) assess the contribution of fish body size to the variation in consumption rate, and 3) evaluate the degree to which the variation in consumption rates among individuals was repeatable. By using brine shrimp (*Artemia*) as prey, we conducted a series of short-term (2-hr) inout-output predation trials in which we exposed single winter flounder of varying sizes (9 to 30 mm total length) to constant densities of instar I *Artemia* nauplii. The magnitude of variation in consumption rates among individuals was substantial (from 0 to > 225 nauplii hr^{-1}). The number of nauplii consumed tended to increase with flounder body size, but the clearest relationship existed for the maximum number of nauplii consumed for a given size of flounder. The latter relationship serves as a better estimate of an upper bound on size-specific consumption rates of juvenile winter flounder. The level of intra-individual repeatability in consumption rates was remarkably high (R^2=0.83), indicating that the variation we observed in consumption rates on any given set of trials was not due to within-individual inconsistencies in appetite or capability. We also ran trials of longer duration (24 hr) on a subset of individuals and repeated trials on some individuals at several-week intervals. These extensions showed that our findings from 2-hr trials are predictive of consumption over a 24-hr period and, more importantly, that the consumption rates exhibited in short-term trials early in juvenile life are predictive of a fish's performance at later dates.

Morphological Transitions During the Early Ontogeny of Windowpane, *Scophthalmus aquosus*

Melissa J. Neuman and Kenneth W. Able

Rutgers University Marine Field Station
Institute of Marine and Coastal Sciences
800 c/o 132 Great Bay Blvd., Tuckerton, NJ 08087

Morphological transitions occurring during the transformation from the larval to the juvenile stage in a temperate flatfish, windowpane, *Scophthalmus aquosus*, were examined in order to gain further insights about the duration and significance of this dynamic period. We collected young-of-the-year (YOY) windowpane in a southern New Jersey estuarine system during spring and fall spawning events (n 158, 4-54 mm TL). Windowpane were characterized according to flexion stage, eye migration, scale formation, fin ray development, pigmentation patterns, lateral line development, and degree of development and ossification of gill rakers, fins and jaws. We found significant differences among larval (about 4-10 mm TL), early demersal (recently settled; about 11-33 mm TL) and juvenile fish (about 34-54 mm TL) in most of these morphological characters. In addition, we found a high degree of variation (CV) in size at the onset and completion of many characters suggesting that windowpane metamorphosis and settlement may occur over a broader size range than previously thought. We propose that the morphological differences among YOY windowpane, in conjunction with behavioral differences identified in an earlier study, may be used to make predictions about the timing of metamorphosis and settlement relative to size of an individual and may serve as markers for distinguishing between ontogenetic stages.

Dermatitis of Juvenile Summer Flounder

Roxanna Smolowitz[1], Edward Baker[2], and Robert Bullis[1]

[1]*Marine Biological Laboratory*
Laboratory for Aquatic Animal Medicine and Pathology (LAAMP)
7 MBL Street, Woods Hole, MA 02543

[2]*PVC Corporation*
Fall River, MA 02720

During the period from February 1998 to April 1998, moribund and dead summer flounder, *Paralichthys dentatus*, were submitted to LAAMP for examination. Flounder were submitted by two different grow-out operations from three different locations in Massachusetts, ranging in size from 8-12 cm in length (juveniles). Various conditions were noted, but the two most immediate problems identified were Trichodinal dermatitis of the eyed head and severe ulcerative bacterial dermatitis of the eyed head. Mortality was associated with both problems. In the first case, mortality was constant, low to moderate (10-20 fish per day), and was controlled with formalin treatment. Unfortunately, treatment needed to be repeated on almost a weekly basis to keep the infestation under control. In the second case, mortality was severe and rapid with loss of almost the entire stock in one facility. In these animals severe focally extensive ulcerative dermatitis and cellulitis was noted. Bacteria cultured from the blood and dermal lesions in these animals included several *Vibrio* spp. and a *Pseudomonas* sp. While causes of these disease problems may have appeared to have different origins, some underlying factors were identified, including: the location of the primary lesions; age of the flounder; temperature/season; and start-up status of the submitting facilities.

Assessment of Young-of-the-Year Winter Flounder Habitats Using RNA as an Index of Condition

Catherine Kuropat[1], Renee Mercaldo-Allen[1], Ronald Goldberg[1], Frederick Thurberg[1], and Beth Phelan[2]

[1]*National Marine Fisheries Service*
Milford Laboratory
212 Rogers Avenue, Milford, CT 06460

[2]*National Marine Fisheries Service*
James J. Howard Marine Sciences Laboratory
74 Magruder Road, Highlands, NJ 07732

Young-of-the-year winter flounder were field-collected and then redeployed in cages within geographically distinct estuaries: the Hammonassett River in Clinton, Connecticut; the Navesink River in Sandy Hook, New Jersey; and Great Bay/Little Egg Harbor in Tuckerton, New Jersey. Cages were placed in one of several different habitat types including eelgrass and macroalgal sites, adjacent unvegetated areas, and a marsh creek. RNA analysis of white muscle tissue was used to assess the influence of habitat type on growth rate. A strong correlation between somatic growth and RNA concentration suggests that RNA is a good measure of growth in juvenile flounder.

Glycine Stimulates Teleost Renal Tubule Organic Anion (OA) Secretion*

J. L. Renfro[1,2], D. S. Miller[1,3], M. A. Dawson[2], S. G. Lechter[1], S. Fujukawal[1], and B. Toomey[1,3]

[1]Mt. Desert Island Marine Biological Laboratory
Box 35, Old Bar Harbor Road, Salsbury Cove, ME 04672

[2]University of Connecticut
Department of Physiology and Neurobiology
Box U-156, 3107 Horsebarn Hill Road
Storrs, CT 06269

[3]Laboratory of Pharmacology and Chemistry
Box 12233
NIH-NIEHS, Research Triangle Park, NC 27709

The renal proximal tubule is an important site of secretion of organic anion. Glycine may prevent hypoxic injury in this tissue by a process involving a glycine-gated anion channel. We examined the relationship of OA secretion and glycine in killifish proximal tubules, masses of winter flounder renal tissue, and monolayers of flounder proximal tubule cells in primary culture (PTCs). Uptake of the OA, fluorescein (FL), was determined in isolated tubules and masses; PTCs mounted in Ussing chambers were used to measure 14C-para-aminohippuric acid (PAH) fluxes. Anoxia (N2, 0.5h) ± 5mM glycine was followed by measurement of FL uptake into cellular (C) or luminal (L) compartments during 30 min reoxygenation yielding: control: (C) 29 ± 2.3, (L) 82 ± 9.1; anoxia: (C) 26 ± 1.9, (L) 37 ± 3.6; anoxia + glycine: (C) 38 ± 3.4, (L) 111 ± 10.5. Glycine stimulated at 2 mM and approached maximum effect at 10 mM. Phorbol ester inhibition of FL uptake was prevented by glycine, which stimulated initial uptake 102 ± 38%. PAH transport by PTCs showed leak flux of PAH was unaffected by 5 mM glycine whereas secretory flux was significantly increased 25%. Glycine was most effective when placed in the peritubular side and had no effect from the luminal side. Strychnine was as effective as glycine in the ìM range, and the effects of glycine and strychnine were not additive. Glycine significantly stimulated organic anion secretion through several possible pathways.

---

*Supported by NSF IBN9604070, MDIBL Salsbury Cove Res. Fund, and NIEHS P30-ES 3828.

Size-specific Predation on Juvenile Summer Flounder, *Paralichthys dentatus,* and the Duration of the Window of Vulnerability

Stephanie Barbeau[1], Christopher Chambers[2], David Witting[2], and Kenneth Able[3]

[1]*Rutgers University*
CMER, Graduate Program in Ecology and Evolution
Foran Hall, 59 Dudley Road, New Brunswick, NJ 08901

[2]*National Marine Fisheries Service*
James J. Howard Marine Sciences Laboratory
74 Magruder Road, Highlands, NJ 07732

[3]*Rutgers University, Marine Field Station*
800 Great Bay Blvd, Tuckerton, NJ 08087

Predation is a major source of mortality during the early life history of many marine fishes. In the juvenile stage, recently metamorphosed flatfish may be especially susceptible to predation. Even then, however, the outcome of an encounter between predator and prey is likely to be determined by their relative body sizes. To investigate size-specific predation risk we: 1) quantified the influences of body sizes on the probability of predation on juvenile summer flounder, *Paralichthys dentatus,* 2) compared the vulnerability of summer flounder to two different predators, sevenspine bay shrimp, *Crangon septemspinosa*, and blue crab, *Callinectes sapidus*, and 3) determined how temperature effects summer flounder growth rates, and, therefore, the duration of time that they are vulnerable to a given size of predator. We reared recently metamorphosed summer flounder at multiple temperatures to provide us with a range of sizes of summer flounder for the predation trials and to estimate temperature-dependent growth rate of juvenile summer flounder. To assess the impact of relative body sizes on prey survival, we used one-on-one trials between predator and prey. Results from over 150 trials show that the risk of predation decreased with increasing prey size and decreasing predator size. This size-specific risk of predation and the results of the temperature-dependent growth study allowed us to estimate the duration of time that summer flounder are vulnerable to these predators.

A Microbiological Survey of Larval Summer Flounder and their Culture Environment at a Commercial Aquaculture Facility

Stephen D. Eddy[1], Stephen H. Jones[1], George Nardi[2], and Beata Summer-Brason[1]

[1]*University of New Hampshire*
Jackson Estuarine Laboratory
Durham, NH 03824

[2]*GreatBay Aquafarms*
153 Gosling Road
Portsmouth, NH 03801

Commercial production of marine finfish larvae and fingerlings can be either adversely or beneficially affected by the microbiology of the culture environment. Diseases caused by pathogenic and opportunistic bacteria can incur substantial losses, while other microorganisms, known as probiotics, can competitively exclude pathogens and aid in the health and nutrition of the fish. At GreatBay Aquafarms, the first commercial facility to grow summer flounder, a microbiological survey of the fish and its culture environment was initiated to identify pathogens and probiotics as part of an overall strategy to improve the health and survival of this fish. Samples of the water, live feed, and fish were collected from a succession of production runs in 1996 and 1997. The samples were processed, diluted and plated on TSA, VAM, TCBS, and marine agar in order to enumerate and identify total heterotrophs, total vibrios, and *Vibrio anquillarum*. Differences in microbial communities at different fish developmental stages and between the live feeds were observed. Total heterotrpohs and vibrios were detected at high concentrations during elevated mortality events. In separate experiments, larval fish were challenged with a potentially pathogenic *Vibrio* sp. previously isolated from sick larval fish by bioencapsulating it in the brine shrimp used as a live feed. This technique resulted in a significant mortality of 40%. The results provide an initial database for determining the role of bacteria in the health of larval summer flounder, as well as a technique for introducing probiotic bacteria into the feed and the fish.

How Do Witch Flounder Cope With an Extended Larval Period?

Jessica H. Rabe and Joseph A. Brown

Memorial University of Newfoundland
Ocean Sciences Centre
St. John's, Newfoundland, Canada A1C 5S7

The witch flounder (*Glyptocephalus cynoglossus*; grey sole) is a commercially important flatfish in the North Atlantic. It has several interesting life history characteristics including a long larval period and a large size at metamorphosis. Due to its high market value we are currently investiagting the potential of this species for cold-water aquaculture. Our research focuses on the live prey requirements of witch flounder larvae. Two complementary experiments are underway to determine the prey concentration required for rearing witch flounder larvae. These experiments can also help elucidate how this species copes with an extended larval period in the wild.

In experiment 1, witch flounder larvae were reared at three different live prey densities (2000, 4000, and 8000 prey/liter) in 33 L flow-through glass aquaria. The density of live prey (enriched rotifers and *Artemia*) was adjusted to the nominal density three times daily. Larvae were sampled weekly for growth and mortality was recorded daily.

Experiment 2 focused primarily on the foraging behavior of witch flounder larvae in response to different prey densities. Twice weekly, larvae were removed from a general rearing tank and placed in 2-L glass bowls containing different concentrations of prey (250, 500, 1000, 2000, 4000, 8000, and 16000 prey/L). After a 5-minute acclimation period the foraging behavior of individual larvae was recorded for 2 minutes.

Preliminary results supports the idea that the prey requirements of witch flounder larvae are lower compared to other cold-water flatfish, which may relate to higher assimilation efficiencies or lower requirements for growth.

Dietary Variation of Age-0 Winter Flounder in a New Jersey Estuary

Linda L. Stehlik and Carol J. Meise

National Marine Fisheries Service
James J. Howard Marine Sciences Laboratory
74 Magruder Road, Highlands, NJ 07732

Potential sources of dietary variation in fishes include ontogeny (size), season, and location. To explore dietary variation in young-of-the-year winter flounder, we collected fish by beam and otter trawl during a 2-year, 84-station survey of the Navesink River-Sandy Hook Bay estuary. Diet items were analyzed using cluster analysis by predator size class and season. Cluster analysis indicated that the young fish could be divided into two size groups: 10-60 mm and 61-120 mm.

Diets varied both spatially and temporarily within size class. For example, in May 1997, calanoid copepods dominated the diet of very small (10-60 mm) fish in the river; while spionid and other polychaetes were the primary prey items at most stations in the bay. Concurrently, diets of larger fish in both river and bay samples contained a wider variety of organisms, including large portions of spionids and ampeliscid amphipods. Diets in July 1997 were similar, with the addition of gammarid amphipods and various polychaetes, and the omission of calanoids. At a few bay stations, diets were composed mainly of ampeliscids. Dietary variation is examined in the context of spatial and temporal factors and the availability of prey as determined from benthic samples.

Species-specific Predation on Natural Zooplankton by Newly-settled Winter Flounder, *Pseudopleuronectes americanus*

Patricia Shaheen[1], Linda Stehlik[2], and John Manderson[2]

[1]*Rutgers University*
Institute of Marine and Coastal Sciences
PO Box 231, New Brunswick, NJ 08903

[2]*National Marine Fisheries Service*
James J. Howard Marine Sciences Laboratory
74 Magruder Road, Highlands, NJ 07732

The consumption of natural zooplankton by newly-settled winter flounder, *Pseudopleuronectes americanus*, was investigated in the Navesink River-Sandy Hook Bay estuarine system, NJ, in May-June, 1998. The study was initiated because an examination of the stomach contents from 155 newly-settled winter flounder collected in a May 1997 survey had yielded puzzling results: (1) the conspicuous absence of the calanoid copepod, *Acartia tonsa*, an historically abundant late spring species; and (2) the presence of the calanoid copepod, *Eurytemora affinis*, which usually is not numerically dominant in late spring. The epibenthic zooplankton community was assessed by sampling nine transects, with 27 stations, using a closing plankton net. Newly-settled winter flounder were collected concurrently with otter and beam trawls. Zooplankton analysis showed *A. tonsa* and *E. affinis* as the major components of the holoplankton throughout the system. Although the abundance of *A. tonsa* was substantial from the head to the middle of the river, *E. affinis* was numerically dominant. *A. tonsa* was the most abundant in the bay, with few *E. affinis* observed. *A. tonsa* was never consumed by newly-settled winter flounder even while abundant in the plankton, corroborating findings from the 1997 survey. *E. affinis* was the sole calanoid copepod found in the newly-settled winter flounder stomachs during the 1998 study. The feeding behavior persisted even where *E. affinis* was low in numbers in the plankton, suggesting a species- specific predation. *A. tonsa* is the most abundant calanoid copepod in northeastern United States estuaries from late spring to early winter, with a year-long numerical dominance which surpasses that of E. *affinis*. Our findings suggest that newly-settled winter flounder do not utilize or rely upon one of the most abundant food resources in North American estuarine systems.

Field and Laboratory Observations on Spawning Feeding and Locomotion in Winter Flounder

Allan W. Stoner, Allen J. Bejda, John P. Manderson, Beth A. Phelan, Linda L. Stehlik, and Jeffery P. Pessutti

National Marine Fisheries Service
James J. Howard Marine Sciences Laboratory
74 Magruder Road, Highlands, NJ 07732

Field collections in the Navesink River estuary (New Jersey) and long-term observations in a large research aquarium (121 kl) were combined to explore the behavior of winter flounder before, during, and after the spawning season. Males and females arrived in the estuary in ripe spawning condition, and fish with high gonadosomatic indices were collected during most of February and March, 1997. All of the ripe females were >20 cm in total length and ≥ 2 years old, whereas ripe males were collected as small as 10 cm (age 1). In the field, females began feeding earlier in the season than males, primarily on siphons of the clam *Mya arenaria* and on ampeliscid amphipods. In the laboratory, males began feeding only after spawning had ended.

Ten male and ten female winter flounder were videotaped continuously in the research aquarium. During the pre-spawning period, the fish were inactive at 20 ºC, except for short feeding bouts. Thereafter, locomotor activity, swimming speed, and feeding frequency were all inversely related to declining water temperature. Males and females were strictly nocturnal during the reproductive season, but became active during the day and night during the post-spawning season. The flounder spawned over a 60-day period at 4 ºC, with an average of 40 spawns per female and 147 spawns per male. Spawning, always initiated by males, occurred primarily between sunset and midnight. Paired spawning was not common (22% of events) because spawning behavior frequently elicited rapid approaches and group spawning by as many as six secondary males. Multiple parentage would appear to be the outcome of most spawning events, and it is clear that male spawning strategy is adapted for maximum fertilization of eggs.

Variation in Reproductive Output of Mid-Atlantic Bight Flatfishes

Peter Berrien and Christopher Chambers

National Marine Fisheries Service
James J. Howard Marine Sciences Laboratory
74 Magruder Road, Highlands, NJ 07732

Reproduction is critical to the series of events that eventually determines the level of recruitment in fish populations. Although both reproductive output and recruitment vary, whether they co-vary in any repeatable way remains a largely unresolved question. A fundamental step in answering this question is to ensure that the variation in reproductive output has been accurately depicted. In this project, we use historic databases and archived ichthyoplankton collections to assess the patterns and sources of variation in reproductive output. We consider 'reproductive output' to include measures such as 1) the duration of the spawning season, 2) the amount of eggs produced during the spawning season, 3) the within-season pattern of egg production, and 4) the quality of eggs as can be deduced from their sizes. We have used information from MARMAP and other data bases, and original size measurements from archived icthyoplankton samples, to initiate these retroactive analyses. The first set of species that we have considered are flatfishes that are abundant in shelf waters of the NW Atlantic. Here we present preliminary results on variation in reproductive output of summer flounder, *Paralichthys dentatus*, yellowtail flounder, *Limanda ferruginea*, and windowpane, *Scophthalmus aquosus*, giving emphasis to alternative hypotheses concerning changes in egg sizes during the course of the spawning season. We conclude that seasonal trends in egg size are likely to be driven by seasonal changes in water temperature.

How Important is the Green Crab, *Carcinus maenas*, as a Predator of YOY Winter Flounder, *Pseudopleuronectes americanus*?

Elizabeth A. Fairchild and W. Hunting Howell

University of New Hampshire
Coastal Marine Laboratory
PO Box 474, New Castle, NH 03854

As young-of-the-year (YOY) flatfish grow, they achieve size refuges in which they are no longer vulnerable to a series of predators. It has been shown, for example, that from settlement to 20 mm TL, YOY winter flounder, *Pseudopleuronectes americanus*, are vulnerable to predation by the sevenspine bay shrimp, *Crangon septemspinosa*. Once beyond this period of shrimp predation, it has been suggested that the fish enter into another period in which they are susceptible to predation by green crabs, *Carcinus maenas*. To investigate this, a 5 x 6 factorial predator-prey size relationship experiment was conducted at the University of New Hampshire's Coastal Marine Laboratory. Five winter flounder size- class treatments (11-20, 21-30, 31-40, 41-50, and 51-60 mm TL) were tested against five green crab size-class treatments (11-20, 21-30, 31-40, 41-50, and 51-60 mm carapace width). Five replicate trials were conducted for each combination, and a control treatment of flounder only (no crabs) ensured all fish mortality was due to predation. Preliminary data show that green crabs greater than 20 mm prey on YOY winter flounder. Flounder of all size classes were preyed on by green crabs, however, as expected, mortality was highest in large crab-small fish combinations.

Substratum Preference by Young-of-the Year Winter Flounder, *Pseudopleuronectes americanus*, and the Influence of Food

Beth A. Phelan and John P. Manderson

National Marine Fisheries Service
James J. Howard Marine Sciences Laboratory
74 Magruder Road, Highlands, NJ 07732

Laboratory and field results were used to determine the role of sediment selection in habitat choice. Young-of-the-year winter flounder, ranging in size from 15 to 69 mm, were separated into 10-mm size groups. Winter flounder were then given a choice of sediment types over a 24-hr period in circular tanks with filtered flow-through seawater. Small individuals (< 40 mm SL) preferred finer-grained sediments, while larger individuals (≥40 mm SL) preferred coarser-grained sediments. No size groups preferred sediments that prevented burial. These results were then compared to field data on the abundance and distribution of juvenile winter flounder synoptically collected with sediments samples from the Navesink River/Sandy Hook Bay estuarine system in New Jersey. In the field, variation in abundance and distribution was related to sediment characteristics (grain size and percent organics) during the 1997 settlement period. However, these patterns changed temporally along with an increase in winter flounder size. Other laboratory experiments determined that the presence of a live food source, the softshell *Mya arenaria*, was sufficient to influence young-of-the-year winter flounder sediment selection, indicating that food forms another significant part of the distributional relationship.

Predation by Striped Searobin (*Prionotus evolans*) on Age-0 Winter Flounder (*Pseudopleuronectes americanus*) and an Alternative Invertebrate Prey (*Crangon septemspinosa*)

John P. Manderson[1], Beth A. Phelan[1], Linda L. Stehlik[1], Allen J. Bejda[1], and Michael Nunez[2]

[1]National Marine Fisheries Service
James J. Howard Marine Sciences Laboratory
74 Magruder Road, Highlands, NJ 07732

[2]Rutgers University
Institute of Marine and Coastal Sciences
PO Box 231, New Brunswick, NJ 08903

Laboratory experiments and data from gillnet and otter trawl surveys in the Navesink River/Sandy Hook Bay estuarine system, New Jersey, were used to examine the importance of striped searobin, *Prionotus evolans,* as predators of age-0 winter flounder, *Pseudopleuronectes americanus.* Although crustaceans (primarily sand shrimp*, Crangon septemspinosa)* were the primary food item in searobin stomachs, large numbers of age-0 winter flounder occurred in diets of fish collected in shallow (<5 m) nearshore areas in Sandy Hook Bay. Winter flounder (12-48 mm standard length [SL]), occurred in 68% of searobins collected in a single gillnet sample (N=35, 152-315 mm SL), with individual fish consuming as many as 11 winter flounders. Laboratory experiments conducted to determine body size relationships between striped searobin predators (185-270 mm SL) and winter flounder prey (20-108 mm SL) showed that the maximum size of prey consumed generally increased with predator size and 95% of prey/predator body size ratios were below 0.28 (Range 0.10-0.40). During day and night prey selection experiments, in which equal numbers of winter flounder (30-54 mm SL) and sand shrimp (30-50 mm TL) were offered to searobins, prey consumption was higher during daytime experiments, but prey choice was random. Searobin prey choice was also random in daytime switching experiments (flounder:shrimp; 5:15, 10:10 and 15:5). Video observations showed that searobins used modified pectoral fins to locate and flush winter flounder during most successful attacks. These results suggest that striped searobins are efficient and opportunistic predators of demersal prey and may consume large numbers of age-0 winter flounder when the species co-occur in shallow nearshore areas.

Using Winter Flounder Growth Rates to Assess Habitat Quality across an Anthropogenic Gradient in Narragansett Bay, Rhode Island

J. Christopher Powell[1] and Lesa Meng[2]

[1]*Rhode Island Division of Environmental Management*
Fish and Wildlife
150 Fowler Street, Wickford, RI 02852

[2]*U .S. Environmental Protection Agency*
Atlantic Ecology Division
27 Tarzwell Drive, Narragansett, RI 02882

We used winter flounder growth rates to assess habitat quality across an anthropogenic gradient in Narragansett Bay, Rhode Island. Cages (1 m^2) were placed in the Providence River (upper bay), Prudence Island, an estuarine reserve (mid-bay), and Sheffield Cove in the lower bay. Individually marked fish were placed in the cages and growth rates were measured over three approximately two-week experiments from 8 June-22 July. Water temperature, salinity, dissolved oxygen, organic carbon, dissolved inorganic nitrogen, chlorophyll A, and benthic food were also measured. Growth rates ranged from 0.22 to 0.63 mm/day and were generally highest at Prudence Island (mid-bay) and lowest in Sheffield Cove (lower bay). Growth rates were initially highest in the Providence River (the most human-impacted site), but dropped off for the second and third experiments, presumably due to low dissolved oxygen. Growth rates obtained in our Narragansett Bay experiment are similar to those obtained in Rhode Island's coastal ponds, Mount Hope Bay, and in other Northeastern estuaries. Results of this study and previous work suggest winter flounder growth rates are driven primarily by larger forces, such as initial fish size, time of year, and latitude, rather than by habitat type.

Comparative Survival and Behavior of Hatchery-reared Versus Wild Summer Flounder: A Laboratory Approach

Todd Kellison

North Carolina State University
Department of Marine, Earth, and Atmospheric Sciences
Raleigh, NC 27695

Stock enhancement is receiving increasing attention as a management option to assist in the rebuilding of depleted fishery stocks. Because behavioral patterns of hatchery-reared (HR) fish are often anomalous to those of their wild conspecifics, it is critical to investigate the ability of HR fish to survive in the natural environment before stock enhancement efforts proceed. In the southeastern United States, the summer flounder, *Paralichthys dentatus*, has been identified as an excellent candidate for stock enhancement programs. I describe the use of laboratory trials to compare behavior and susceptibility to predation of HR versus wild juvenile summer flounder.

Predation trials consisted of introducing a blue crab, *Callinectes sapidsus*, as a predator to a tank containing a (1) wild fish, (2) naïve HR fish, or (3) predator-conditioned HR fish. Predation trials were replicated on both sand (n=33/treatment) and mud (n=20/treatment) substrates in an attempt to investigate habitat-specific differences in survival. Trials lasted for 24 h, after which the predator was removed and the fish classified as eaten or not eaten. HR fish suffered significantly higher predation than wild fish, irrespective of substrate type. Predator-conditioned fish exhibited survival rates which were greater than naïve HR fish but less than wild fish. These results were consistent across substrates. In an attempt to understand the mechanisms underlying these survival patterns, replicated behavioral observations were made for both HR and wild fish on sand (n=38) and mud (n=38) habitats. Time spent performing certain behaviors (*e.g.*, swimming in the water column, moving on bottom, buried, *etc.*) was recorded and compared between treatments. HR fish spent significantly more time swimming in the water column than wild fish, whereas wild fish spent significantly more time buried or motionless on the benthos than HR fish. These results suggest that the anomalous behavior patterns of HR fish cause increased susceptibility to predation. Results from the predator-conditioning trials suggest that it may be possible to mitigate behavioral deficits by exposing naïve HR fish to natural stimuli before they are released into natural environments.

Habitat Utilization of Juvenile Summer Flounder in the Virginia Portion of the Chesapeake Bay

Richard T. Kraus and John A. Musick

College of William and Mary
School of Marine Science, Virginia Institute of Marine Science
PO Box 1346, Gloucester Point, VA 23062

The recent mandate of Essential Fish Habitat (EFH) identification in the Magnuson-Stevens Fishery Management Act, 1997, and the adoption of summer flounder, *Paralichthys dentatus*, as the model species for an EFH identification prototype has required the synthesis and evaluation of available habitat utilization data. Summer flounder is a highly migratory species with a dynamic life history; therefore, ontogenetic stages are treated separately when considering habitat utilization. The highest quality habitat data are available for the inshore juvenile stage, thus most of the work on juvenile flounder habitat has focused on the inshore juvenile habitat. Independent analysis of habitat variables has allowed little comparison of relative effects, although some workers have simultaneously analyzed two or three variables. The objective of this study was to analyze the relative effects of ten variables {temperature, salinity, dissolved oxygen, depth, substrate, slope of the bottom, distance to submerged aquatic vegetation (SAV), distance to the Bay mouth, tide, year}on the occurrence of juvenile summer flounder in the Virginia portion of the Chesapeake Bay through analysis of VIMS long-term unpublished monitoring data. Variables, not measured directly, were applied to the flounder data from various source data using the Geographic Information System (GIS), ARC/INFO. Reduced multiple logistic regression models of the occurrence of summer flounder in catches were developed for each season. Response surfaces were visualized geographically with ARC/INFO by combining generalized source data maps using parameter estimates from the regression models.

Comparison of Models for Defining Nearshore Flatfish Nursery Areas of Flatfishes in Alaskan Waters

Brenda L. Norcross, Arny Blanchard, and Brenda A. Holladay

University of Alaska Fairbanks
Institute of Marine Science
PO Box 757220, Fairbanks, AK 99775

Assessment of nursery habitats of Northeast Pacific flatfishes in Alaska is difficult because of the many thousands of kilometers of coastline. As it is unrealistic to assess fishes in all locations, models are needed to characterize the nursery habitats of flatfish species. Descriptive habitat models of species presence and categorical analysis regression tree (CART) models of species abundance have been developed in previous studies. Based on collections around Kodiak Island, Alaska in 1991 and 1992, these models have been developed for: age-0 flathead sole, *Hippoglossoides elassodon*, age-0 Pacific halibut, *Hippoglossuss stenolepis*, age-1 yellowfin sole, *Pleuronectes asper*, and age-0 rock sole, *Pleuronectes bilineatus*.

In 1995, collections were made in bays along the Alaska Peninsula (an area never before sampled for juvenile flatfishes) separated by 50 km from Kodiak Island across Shelikof Strait, and these collections were compared with the previous models developed for Kodiak Island in 1991 and 1992. Very simple descriptive models (Norcross *et al.* 1995) accurately predicted the presence of flathead sole (78%), Pacific halibut (96%), yellowfin sole (75%), and rock sole (99%) in specific depth ranges and on specific substrate types. More complex CART models of species abundance (Norcross *et al.* 1997) were more precise but not as accurate as the descriptive models because some parameters were not always available at the test locations. Flathead sole were found at temperatures ≤ 8.9 ºC on mud and mixed mud substrates in similar proportions in 1995 (66%) as in 1991-1992 (71%). Similarly, Pacific halibut were ≤ 7.9 km inside bays and at depths ≤ 40 m in 93% of the sites of this study, compared with 89% previously. Seventy-five percent of yellowfin sole were at depths ≤ 28 m on mixed substrates in both study periods. Rock sole were found on sand and muddy sand substrates at temperatures above 8.7 ºC in 52% of the sites in present and 69% of the sites in previous studies.

This field test demonstrated that both descriptive and CART models were very useful at identifying juvenile habitat parameters. However, those models did not fully accomplish the goal of this research, which was the production of simple but reasonably accurate and precise habitat models that can be applied to areas not previously sampled. The resource selection models developed here verified the importance of a subset of parameters used in earlier models and provided a statistical means (78-87% correct) for prediction of fish distribution in similar areas of the eastern North Pacific.

Habitat-specific Utilization of Nursery Grounds in Juvenile Summer Flounder, *Paralichthys dentatus*: A Mark-recapture Experiment

J. Christopher Taylor

North Carolina State University
Department of Zoology
115 David Clark Laboratories
Raleigh, NC 27695

Juvenile estuarine-dependent fish such as the summer flounder, *Paralichthys dentatus,* utilize a variety of habitats during their early life history. A mark-recapture experiment was used to compare growth, survival and residency in two types of inter-tidal habitats: a high energy sand flat, and a low energy flat adjacent to a Spartina marsh. Fish were tagged and released at the beach (n=117) and marsh site (n=92) from May 12-July 17, 1998. Recapture rates were higher on the beach with 38.5% one-time recaptures and 10 % two-time recaptures. In contrast, the marsh recapture rates were lower, with 17.4% recaptured once and 6.6% recaptured twice. Average residence times were 11 d (range 1-37 d) on the beach and 10 d (range 2-34 d) on the marsh, suggesting that the flounder utilize the beach for longer periods of time than the marsh. Direct measures of growth through tag returns were 0.17 mm/d in the marsh and 0.43 mm/d on the beach. High recapture rates suggest that nonvegetated, inter-tidal flats are critical habitat for juvenile summer flounder; however, apparent differences in growth and residence time between different types of habitat suggest that productivity on flats vary. We plan to expand our research concentrating on factors governing productivity in inter-tidal habitats.

A Long-term Study of Settlement and Growth Patterns in Young-of-the-Year Winter Flounder in New Jersey Estuaries

Susan M. Sogard[1] and Kenneth W. Able[2]

[1]*National Marine Fisheries Service*
Hatfield Marine Science Center
Newport, OR 97365

[2]*Rutgers University Marine Field Station*
800 c/o 132 Great Bay Boulevard
Tuckerton, NJ 08087

The timing of settlement and subsequent growth patterns during the early juvenile stage can potentially regulate survival and year-class strength in marine fishes. We examined spatial and interannual differences in settlement and growth of winter flounder across a nine-year time series. Young-of-the-year fish were collected in late May/early June from four sites spanning the coastline of New Jersey (Sandy Hook, Barnegat Bay, Great Bay, and Wildwood). Overall, size frequency distributions suggested a narrow time period of settlement in late spring. Within this period there were some consistent inter-site and interannual differences in size distributions. For example, when sizes were standardized to a common sampling date of May 30, age-0 fish were smaller in 1994 and 1996 across all sites, suggesting later settlement. Across sites, winter flounder were consistently larger at the southernmost sampling location (Wildwood) and were generally smaller on average at the northernmost site (Sandy Hook). This pattern suggests a seasonal progression of settlement from southern to northern sites, but the trend needs to be confirmed with otolith analysis of settlement dates. Density estimates based on standardized seine tows did not indicate consistent interannnual trends among sites. Sandy Hook typically had the highest densities and Great Bay the lowest densities.

Quantifying Otogenetic Change: A Multivariate Analysis of Larval Development in Flatfishes

Heather Hamlin, Christopher Chambers, and David Witting

National Marine Fisheries Service
James J. Howard Marine Sciences Laboratory
74 Magruder Road, Highlands, NJ 07732

Change in size, shape and features are characteristic of the larval stage of marine teleosts. Ontogenetic change in larval flatfishes is particularly dramatic, as exemplified by the eye migration that is the hallmark of this order. To be accurate, however, it must be recognized that ontogenetic change in larval flatfishes occurs continuously in a multitude of features each with its own rate of transition. The challenge to fisheries ecologists is to portray these changes fairly while generating a larval staging scheme that is of utility for quantifying and interpreting processes in natural populations. Here we review features of various staging schema and provide a framework for reconsidering these in light of flatfish ontogeny and the application of this information to natural populations. We present preliminary data on ontogenetic change in winter flounder, *Pseudopleuronectes americanus*, and windowpane, *Scophthalmus aquosus*, and demonstrate how ontogenetic progressions of multiple features might be best quantified and compared.

Effects of Pier Shading on the Growth of Juvenile Winter Flounder, *Pseudopleuronectes americanus*

Janet Duffy-Anderson and Kenneth W. Able

Rutgers University Marine Field Station
800 c/o 132 Great Bay Boulevard
Tuckerton, NJ 08087

Urban estuaries support human activities and are important areas for fishes. We previously evaluated these potentially conflicting uses by examining growth of juvenile fishes relative to municipal piers in the Hudson River. We found that juvenile winter flounder caged under piers exhibited negative growth while fish in adjacent open water areas grew well. Underpier areas are light-deprived, which may interfere with the feeding ability of visually-feeding fishes. We report the results of experiments designed to examine the effects of shading on feeding and growth of juvenile winter flounder. Two 10-d caging experiments were conducted near a municipal pier in the Hudson River using artificially darkened cages that mimicked the light-deprived conditions of underpier environments. Results suggest that winter flounder may exhibit negative growth in darkened cages, although the effects may be negated when prey availability is not limiting. Feeding success among fishes was evaluated using recently-settled winter flounder in caging experiments of shorter duration. Cages were deployed along an underpier, pier edge, and open water transect for 3 hr, allowing fish an opportunity to feed on available prey items. The contents of the gut were counted and identified, and results indicate both the abundance and diversity of prey consumed may be depressed under piers.

The Interaction of Turbidity and Substrate Preferenda of Winter Flounder, *Pseudopleuronectes americanus*

Paul Grecay and Kevin Stierhoff

Salisbury State University
Department of Biological Sciences
Salisbury, MD 21801

Habitat choice by juvenile fish may reflect adaptations which maximize survival. Because young fish are vulnerable to predation, refuge may be an important component of habitat choice. For flatfishes such as the winter flounder, substrates which provide camouflage or enable partial or complete burial are likely to be preferred. Turbidity, a feature of the water column which is ubiquitous in near-bottom environments, may also provide protection from visual predators. However, it is also likely that high turbidity may negatively impact feeding by juvenile winter flounder. The ecological role of turbidity in the habitat choice by winter flounder is unknown. It is possible that in clear conditions juvenile flounder are more vulnerable to predation by visual predators and are thus more likely to prefer substrates which facilitate complete burial. Thus, prevailing conditions of turbidity may affect substrate choice. In this investigation we examined the substrate preferences of juvenile winter flounder in non-turbid conditions. Because turbidity may confer a survival advantage, turbidity preferences and the influence of turbidity on substrate choice were also examined. Turbidities ranged from 0.95 to 11 NTU and represented conditions commonly encountered in estuarine nursery areas.

Revisions in Flatfish Taxonomy: Sometimes the Names Have to Change

J. Andrew Cooper

National Marine Fisheries Service
Museum of Natural History, Systematics Laboratory
Washington, DC 20560

The genus-level taxonomy in the family Pleuronectidae (right-eyed flounders) has undergone significant revisions in recent years. Changes incorporated in the most recent AFS list of common and scientific names (Robins, *et al.* 1991) were based on a phenetic analysis of species interrelationships (Sakamoto 1984). The revisions proposed by Sakamoto's study affected 26 species in 12 genera. Due to the commercial significance of many of these species, the nomenclature (*sensu* Sakamoto) has been the subject of much scrutiny and confusion. Taxonomic arrangements and nomenclatorial changes proposed in this phenetic study have been disputed and revised in the light of new and more complete information based on a cladistic analysis for this family (Cooper and Chapleau 1998). To the nonsystematist, the basis for these changes is sometimes obscure and not well understood. However, nomenclatorial changes mandated by a cladistic analysis, can be meaningful to both taxonomist and fisheries scientists. Direct comparison of these two recent revisions highlights the utility of the cladistic analysis, especially in studies examining comparative biology, ecology and life history of these commercially important flatfish species.

Using Coded Wire Tags to Study Movement and Growth of Young-of-the-Year Winter Flounder, *Pseudopleuronectes americanus*, in Point Judith Pond, Rhode Island

Riley E. Young-Morse and Conrad W. Recksiek

University of Rhode Island
Fisheries, Animal and Veterinary Science
Woodward Hall, Kingston, RI 02881

A project was conducted during a five-month period from July to December 1996 to investigate the use of coded wire tags as a method for studying individual growth and movement of young-of-the-year winter flounder, *Pseudopleuronectes americanus*, in a coastal pond estuary.

Investigations in the lab examined the retention, survival, and effects on growth of this tagging method. Two hundred fish were captured from Narragansett Bay in July and August of 1996, and were kept in flow-through seawater tanks and fed an artificial diet. Retention of the tags was 100% during the four-month study. Survival seemed dependent on size and health of the fish at capture. Of fish measuring greater than 50 mm at capture, survival was 90-100% in all treatment groups. Fish, smaller than 42 mm at capture, had a 42-90% survival rate in all treatment groups, including the control. Growth did not appear to be impacted by tagging, as control groups had similar growth rates to the experimental treatments.

Field trials utilizing this method occurred in two sites of Point Judith Pond, Rhode Island. Fish were captured using seine nets and SCUBA in a 100-m area from August to November, 1996. Fish were subcutaneously injected on the blind side with a coded wire tag, were marked with a panjet ink tattoo to identify fish carrying the tag, and were then released. Recapture attempts occurred one to three weeks after tagging, and were done at the site of release, 50 m down shore, and 100 m down shore. Of the 250 fish marked and injected with coded wire tags, a 5% recovery was observed in the area up to 100 m from the release site. The longest 'at large' recaptured fish was 10 weeks, and upon recapture both the tag and the ink tattoo were still visible, and the fish appeared in good health. Growth measurements appeared consistent with the lab findings, and did not seem to be affected by the tags.

Results indicate that microwire tagging is an effective and efficient means of tagging juvenile fish that are too small for larger external tags where individual data are desired.

The Foraging Ecology of Yellowtail Flounder, *Limanda ferruginea*, Larvae: Inferences from Laboratory Studies

Joseph A. Brown and Velmurugu Puvanendran

Memorial University of Newfoundland
Department of Biology, Ocean Sciences Centre
St. John's, Newfoundland, Canada A1C 5S7

During the early life stages in fishes, mortality due to starvation is intense. Larval fish are poorly equipped to handle this pressure as they are weak swimmers, have poorly developed sensory and digestive systems, and their behavioral repertoire is limited. Over the past number of years we have been trying to understand how marine fish have adapted to avoid starvation. Our experiments have focused on a number of factors important to larval foraging in the marine environment: light level, prey availability, and type. Our working hypothesis is that marine larvae in the Northwest Atlantic have adapted to "threshold" foraging environments in which their survival is maximized. We have conducted a number of laboratory experiments on yellowtail flounder, *Limanda ferruginea,* larvae to try and define the environments to which they are adapted.

Experimental results suggest that yellowtail larvae require high densities of prey (>4000/l), high light intensity (>2,000 lux) and prefer *Artemia* over rotifers when they reach a length of 7.5 mm. Compared to other marine larvae from the Northwest Atlantic, yellowtail flounder larvae appear to have a similar foraging ecology to Atlantic cod, *Gadus morhua*, but differ significantly from other species.

The Effects of Temperature and Salinity on Feeding, Growth and Survival of Juvenile Summer and Southern Flounder, with a Comparison of Salinity Preference

Ursala A. Howson and Timothy E. Targett

University of Delaware
Graduate School of Marine Studies
Lewes, DE 19958

Summer flounder, *Paralichthys dentatus*, and southern flounder, *P. lethostigma*, enter SAB estuaries as larvae throughout late winter and early spring. Ontogenetic segregation occurs shortly thereafter, with juvenile southern flounder moving upstream to lower salinity nursery areas and juvenile summer flounder tended to remain at higher salinity areas downstream. To determine the ecological significance of this segregation, as well as to delineate important nursery ground conditions in terms of "essential fish habitat", we examined feeding rate, growth rate, and survival of these two species under different temperature/salinity regimes. Experiments were conducted concurrently on both species at 15, 20, 25 and 30ºC; with *P. dentatus* at 10, 20 and 30 ppt salinity and *P. lethostigma* at 0, 10, 20, and 30 ppt salinity. From 15 to 25ºC growth rates for *P. lethostigma* increased with increasing temperature and decreasing salinity. *P. dentatus* did not survive at 0 ppt. Growth rates for *P. dentatus* were generally unaffected by salinity (10-30 ppt) at 15 and 20ºC, but exhibited a trend of increasing growth with salinity at 25 ºC.

To determine whether salinities that promoted the greatest growth were also preferred behaviorally by each species, salinity preferences between *P. dentatus* and *P. lethostigma* were compared. Circular Staaland devices, modified with ramps for flatfish, were designed to maintain salinity gradients for more than 24 hours. Fish were observed remotely for several hours; each trial was videotaped and percent of time spent at each salinity was determined.

Benefits of Green Water: Effects on Growth, Survival, and Time to Metamorphosis of Winter Flounder, *Pseudopleuronectes americanus*

Deborah A. Bidwell and W. Huntting Howell

University of New Hampshire
Coastal Marine Laboratory
PO Box 474, New Castle, NH 03854

The addition of microalgae or "green water" to larval culture systems has recently become an integral part of standard rearing protocol. We examined the effects of varied duration of green water exposure on growth, survival, and time to metamorphosis of larval winter flounder, *Pseudopleuronectes americanus*. Five treatments were employed: clear water (no algae added) and green water addition for 7, 14, 21 and 28 days post-hatch. Algal species utilized were *Duneliella tertiolecta, Nannochloropsis oculata and Tetraselmis suecica.* Larvae from the clear water and the 7-day green water treatments were smaller and grew at slower rates than those in the prolonged green water treatments. At the termination of the experiment larvae exposed to the 21- and 28-day green water treatments had developed further towards metamorphosis than the clear water and the 7-day green water treatments. There were no significant differences in survival between treatments. Based on these results we suggest that green water addition be utilized for the culture of winter flounder larvae at least until the onset of metamorphosis.

The Effects of Feeding Schedule and Frequency of Feeding on Summer Flounder Juvenile Growth in Recirculating Systems

Grace Klein-MacPhee[1], Brian Murphy[2], and Erin Rectisky[3]

[1]University of Rhode Island
Graduate School of Oceanography
Narragansett, RI 02882

[2]University of Rhode Island
Department of Fisheries, Animal and Veterinary Science
East Farm, Kingston, RI 02880

Two sets of experiments were conducted on laboratory-reared, 5-month-old summer flounder juveniles maintained in recirculating systems. The first set of experiments examined the effects of feeding once or twice a day at different time periods. Since summer flounder have been shown to be night active in both the laboratory and the field, and metabolic rates peaked at night, we hypothesized that feeding more frequently would promote faster growth and that optimum growth rates would occur when fish were fed more frequently at night. One set of fish were fed once a day at 9 AM and 11 PM; the second set of fish were fed twice a day at 9 AM and 3 PM, and at 5 PM and 11 PM. All fish received the same percent body weight of food and there were three replicates for each condition.

Results showed that fish fed twice a day grew significantly faster than fish fed once a day, but there were no significant differences between day and night feedings, and there were no interactions between the two conditions. In the second set of experiments fish were fed once, twice, and four times per day. Fish fed twice and four times per day grew significantly faster than those fed once per day, but there was no significant difference between fish fed twice and those fed four times per day.

Variation in Temperature Effects on Embryonic and Early Larval Period Attributes of Winter Flounder, *Pseudopleuronectes americanus*

Christopher Chambers

National Marine Fisheries Service
James J. Howard Marine Sciences Laboratory
74 Magruder Road, Highlands, NJ 07732

Water temperature can have profound effects on events in the early life history of fishes, including accelerations or delays in development and influences on sizes and energy reserves of larvae. This talk presents analyses of temperature effects on the timing of, and sizes at events in the embryonic and early larval stages of winter flounder, *Pseudopleuronectes americanus,* from multiple locations in the specie's range. By using fertilized eggs of winter flounder from New Jersey, USA, to Newfoundland, Canada, and a standard temperature control apparatus, replicated groups of eggs were incubated at 10 different temperatures (range 0-14ºC). Survival to hatching was high for all but the extreme temperatures. The duration of the embryonic period varied from 4 to more than 40 d, and was log-linearly related to incubation temperature (developmental rate exhibited a slightly convex relationship with temperature). Size at hatching was maximal at intermediate temperatures and was inversely related to the amount of yolk sac reserves at hatching. Duration of the yolk-sac period of larvae held at a common temperature after hatching was influenced by the temperatures that these individuals had experienced during the embryonic period. These patterns of early life history traits and their responses to incubation temperatures are interpreted in the context of 1) events later in larval life, 2) general geographic trends in life history traits, and 3) potential consequences in natural populations.

The Basis and Potential Utility of Meristic and Morphological Variation in Winter Flounder, *Pseudopleuronectes americanus*

David Witting and Christopher Chambers

National Marine Fisheries Service
James J. Howard Marine Sciences Laboratory
74 Magruder Road, Highlands, NJ 07732

Meristic and morphological traits have long been used to differentiate species and stocks within species. One shortcoming of such analyses is that these traits can be influenced by environmental conditions. As such, the effects of geographical, interannual, and seasonal environmental variations could potentially be misinterpreted as stock characteristics. In theory, once the influences of environmental variables on these traits are known, this information could be used not only to discriminate stocks better, but also to identify aspects of the environmental history of fish in natural populations. Our research seeks to establish the environmental basis of variation in meristic and morphological traits and then apply the derived relationships to the inverse problem of inferring environmental history. Here we report results from the validation phase of this effort. Larvae of winter flounder, *Pseudopleuronectes americanus*, were reared from hatching to metamorphosis in the laboratory under a range of constant temperatures (7 to 16ºC). At metamorphosis, the flounder were first videotaped for size and shape measurements, then preserved, cleared and stained for enumeration of meristic traits (fin ray and vertebral numbers). We analyzed and present here the temperature dependencies of these traits as a collective suite of characteristics, but argue that meristic and morphological traits differ quantitatively in their utility to infer past environments.

Survival of Larval Winter Flounder, *Pseudopleuronectes americanus*: Evidence for a Critical Period?

Stephen Lewis, Christopher Chambers, and David Witting

National Marine Fisheries Service
James J. Howard Marine Sciences Laboratory
74 Magruder Road, Highlands, NJ 07732

One of the dominant hypotheses in fisheries ecology is that of the ‘critical period’. Since its first articulation by Hjort nearly 85 years ago, this hypothesis has been variously defined and addressed. After first reviewing the alternative definitions of critical period, we present survivorship data for laboratory populations of winter flounder, *Pseudpleuronectes americanus*, which we use to evaluate the patterns of mortality during the larval stage. Replicate populations of winter flounder were reared from hatching to metamorphosis at each of four temperatures (7 to 16ºC). Each population was monitored daily for mortality, and these data were subjected to survival (‘failure time’) analyses.

Overall, survival to metamorphosis was high (26 to 85%) and the survivorship curves were similar among replicates within temperature treatments. Survival was slightly lower at the cooler temperatures. For all temperatures the computed daily risk of mortality (‘hazard function’) was nearly uniform throughout the larval period except for older larvae where mortality increased near the ages of settlement and metamorphosis. This period of higher mortality was amplified in the populations maintained at the coolest temperature. We discuss methods to detect periods of punctuated mortality and other indicators of critical periods.

Effect of Dietary Protein Level on the Growth, Survival, and Feed Performance of Juvenile Summer Flounder, *Paralichthys dentatus*

Nicholas J. King and W. Huntting Howell

University of New Hampshire
Department of Zoology
Durham, NH 03824

Protein requirement for the production of juvenile summer flounder, *Paralichthys dentatus*, was examined using experimental diets containing 45%, 55%, and 57% crude protein. Newly settled summer flounder (19 mm) were fed rations of the experimental diets and sampled for weight, length, and survival. A significant difference ($p < 0.05$) in weight occurred within the three treatments by week 3 (57>55>48). However, after six weeks, fish fed the 57% protein diet had similar growth performance (in weight) to those fed the 55 % protein diet, and were nearly significantly heavier ($p = 0.07$) than fish fed the lowest protein diet (48%). Additionally, weight-specific growth rate directly increased with protein level for the first three weeks of the experiment, but decreased among fish fed the highest protein level during the final three weeks of this experiment. Final mean values for length, weight, survival percentage, weight-specific growth rate, feed efficiency, and protein efficiency were greatest among fish fed the experimental diet containing 55% protein. These results indicate that the optimum dietary protein level for summer flounder decreases from >57% to 55% as juveniles grow from 19 mm to 50 mm. When considering the high cost of protein in manufactured feeds, we recommend a dietary protein level of 55% for juvenile (50 mm) summer flounder. Further research is needed to determine the optimum protein level for newly settled juveniles (19 mm).

Larval Rearing Techniques of Yellowtail Flounder

Velmurugu Puvanendran, Danny Boyce, Nicola Morris, and Joseph A. Brown

Memorial University of Newfoundland
Ocean Sciences Centre
St. John's, Newfoundland, Canada A1C 5S7

Interest in yellowtail flounder, *Limanda ferruginea*, aquaculture is greatest in Atlantic Canada due to the relatively high market value and a ban on commercial fishing. Research on yellowtail flounder culture at the Ocean Sciences Centre has focused on brood-stock management, egg incubation, larval rearing and on-growing. Experiments on larval rearing were initiated in 1994 and focused on the effect of prey concentrations, prey type, light intensity and photoperiod. Results of these experiments will be discussed in terms of behavior, growth and survival.

Abstracts
Poster Presentations

Post-metamorphic Growth of Summer Flounder in Laboratory Culture: Do Early-settling Larvae Grow Faster than Late Settlers?

Tessa L. Simlick, Robin S. Katersky, Neil Marcaccio, and David A. Bengtson

University of Rhode Island
Department of Fisheries, Animal, and Veterinary Science
Kingston, RI 02881

Laboratory-reared summer flounder larvae begin to settle to a benthic existence 30 to 35 days after hatching, but settlement can continue for about a month because completion of metamorphosis among individuals does not occur simultaneously. We perform weekly gradings (*i.e.*, removal of settled flounder) until all fish have settled in order to prevent cannibalism and stress, because newly settled juveniles tend to be larger than swimming larvae. Although we know there is a strong correlation between larval growth and time of settlement (fastest growers settle first), no data exist on post-settlement growth variability. We wanted to determine whether fast-growing larvae become fast-growing juveniles or whether slow-growing larvae can 'catch up' in growth rate. Experiments were designed and conducted at the Narragansett Bay Campus Research Facility to explore these inquiries.

Settled fish were graded from the larval tank at 32 days after hatch (DAH) (Grade 1), 39 DAH (Grade 2), and 46 DAH (Grade 3). Graded fish were placed randomly in three replicate 75-L aquaria per grade, at a density of 30 fish per aquarium. Flounder were fed *Artemia* for 30 days after removal from the larval tank and then weaned onto a commercial diet. All fish were measured using Image Analysis at biweekly intervals until the fish were 95 DAH. No significant differences in post-settlement growth rate were seen among the three grades. In the final set of measurements, the fish exhibited an increase in size variation within replicates and cannibalism attacks were again causing mortality. Future experiments will continue to investigate specific growth rate variation in all stages of juvenile growth.

Effects of Photoperiod on Survival, Growth, and Pigmentation of Summer Flounder, *Paralichthys dentatus*, Larvae in Laboratory Culture

Marina Huber, Eric Moore, Neil Marcaccio, Robin Katersky, and David Bengtson

University of Rhode Island
Department of Fisheries, Animal and Veterinary Science
Kingston, RI 02881

The summer flounder represents a promising species for commercial aquaculture in the northeastern United States. In order to optimize production, the effects of various environmental parameters on biological production parameters must be studied. We investigated the effects of photoperiod on three parameters important to hatchery production: survival, growth and abnormal pigmentation. The last parameter involves incomplete pigmentation of the eyed side, including minor non-pigmented blotches to complete albinism. Flounder larvae were reared in replicate 75-L aquaria under three light regimes, 24L:OD (constant light), 16L:8D (summer conditions), 8L:4D:8L:4D (abnormal conditions to trick the fish into physiologically living two "days" in one). No significant differences in survival or growth were detected in the larvae through metamorphosis; however, after metamorphosis fish reared in constant light had significantly lower levels of abnormal pigmentation. The experiment will be repeated with an additional treatment, 8L:16 D (winter conditions).

Ontogenetic Diet Shifts of Larval and Juvenile Flatfish: Estimating Turnover Rates with Stable-Isotope Ratios

Keith L. Bosley[1], David A. Witting[2], Christopher Chambers[2], and Sam C. Wainright[1]

[1]Rutgers University
Institute of Marine and Coastal Sciences
71 Dudley Road, New Brunswick, NJ 08901

[2]National Marine Fisheries Service
James J. Howard Marine Sciences Laboratory
74 Magruder Road, Highlands, NJ 07732

Stable-isotope ratios of carbon (13C/12C) and nitrogen (15 N/14N) are widely used as indicators of the diet of animals. However, the use of stable isotopes to study ontogenetic diet shifts of larval and juvenile flatfishes depends upon having a knowledge of their turnover rates of carbon and nitrogen. In previous studies using wild-caught juvenile striped bass, *Morone saxatilis*, tautog, *Tautoga onitis*, and winter flounder, *Pseudopleuronectes americanus*, we found very rapid turnover rates of carbon (2-3 d) and less rapid turnover rates of nitrogen (4-17 d). In the present study, these rates were determined for larval winter flounder in the laboratory using the natural abundance of stable isotopes as tracers. Fish were spawned in the lab and maintained at two temperatures (13ºC and 17ºC) on a diet of rotifers of known isotopic composition from the time of first-feeding. At settlement, a subset of fish from both temperature treatments was maintained on rotifers to serve as a control, while the remaining fish were switched to a diet of *Artemia,* which was known to be isotopically distinct. Fish were subsampled at predetermined time intervals, and the rates of metabolic turnover of C and N were determined from plots of stable-isotopic composition as a function of time and weight gain.

Molecular Characterization of Ribosomal DNA from Representative Flatfishes of the US Atlantic Coast*

Pradip R. Kar[1], Z. M. G. Sarwar. Jahangir[2], and Ronald A. Eckhardt[1]

[1]Brooklyn College of CUNY
Brooklyn, NY 11210

[2]The Richard Stockton College of New Jersey
Pomona, NJ 08240

Flatfishes are unique due to the asymmetry in their ocular rearrangements. Although young flatfishes are bilaterally symmetrical, their eyes migrate in adults either to dextral or sinistral cranium depending on the species or individuals. This migration of eyes has been reported to be genetically controlled in *Platicthys stellatus*, so we decided to revisit the phylogeny of closely related flatfishes representing sinistral and dextral ocular rearrangements based on ribosomal DNA (rDNA). The rDNA is known to contain both highly conserved and rapidly evolving domains, hence the rDNA characteristics of distantly as well as closely related fishes can be used to determine their relationships. This study examines whether ocular symmetry in flatfishes is independent of their phylogeny based on rDNA characteristics.

Samples of nuclear DNA were isolated from the blood cells of fishes representing Bothidae, Pleuronectidae and Soleidae and digested with several restriction endonucleases independently or in combinations. The DNA fragments thus generated were separated according to their molecular weights in agarose gels by electrophoresis, transferred to nylon membranes by Southern blotting techniques, and hybridized with digoxigenin-labeled *Xenopus laevis* rDNA probe. The size of each hybrid rDNA fragment was determined following the graphic method and a restriction enzyme map of rDNA was constructed for each sample species. These maps will be compared and analyzed using computer-assisted parsimony analysis to determine their phylogenetic relationships.

---

*Jointly supported by Brooklyn College of CUNY and The Richard Stockton College of NJ.

Size-specific Predation on Recently Metamorphosed Winter Flounder, *Pseudopleuronectes americanus*, and the Duration of their Vulnerability to *Crangon septemspinosa*

David Witting and Christopher Chambers

National Marine Fisheries Service
James J. Howard Marine Sciences Laboratory
74 Magruder Road, Highlands, NJ 07732

The overall risk of predation and the specifics of the predation process are likely to depend on the relative body sizes of prey and their potential predators. We assessed the influence of body size of recently metamorphosed (8 to 30 mm TL) winter flounder, *Pseudopleuronectes americanus*, on their likelihood of being consumed by juvenile and adult (15 to 50 mm TL) sevenspine bay shrimp, *Crangon septemspinosa*. Using one-on-one laboratory-based predation trials, we show that the likelihood of predation on winter flounder by bay shrimp decreases as the flounder increase in size and/or when they are exposed to smaller shrimp. The size at which winter flounder became invulnerable to bay shrimp increased with increasing shrimp size, but occurred in all cases by the time winter flounder reached >25 mm TL. The time taken to reach a size refuge was inversely related to winter flounder growth rate, which, in turn, varied directly with prevailing water temperatures. In order to provide an estimate of the duration of the period of vulnerability of winter flounder to bay shrimp, we reared recently metamorphosed winter flounder under a range of constant temperatures (10 to 19ºC) and report here the degree-days of growth required to achieve a size refuge.

Temperature Effects on Age, Size, and Condition at Hatching in Windowpane, *Scophthalmus aquosus*

Marisa Cook[1, 2] and Christopher Chambers[2]

[1]*Cooperative Marine Education and Research Intern*
[2]*National Marine Fisheries Service*
James J. Howard Marine Sciences Laboratory
74 Magruder Road, Highlands, NJ 07732

Windowpane, *Scophthalmus aquosus*, is a broadly distributed bothid of coastal and inshore waters of the NW Atlantic. It spawns in both spring and autumn in southerly areas of its range, but this temporal bimodality converges to a single spawning season in the north. Temperature appears to be important in determining the timing of spawning, but little information exists on temperature effects on the early life history of windowpane. We expect temperature to be highly influential in fish development and growth rates in general, and it may be particularly important to windowpane ecology, given that young windowpane from the spring spawning event experience increasing temperatures whereas those from autumn spawning experience decreasing temperatures. Our intent in this study was to provide baseline information on temperature effects on embryonic period duration, survival to hatching, size and condition of fish at hatching and survival of yolk-sac larvae. We incubated replicated groups of windowpane eggs from laboratory crosses at multiple constant temperatures (7 to 21ºC) and checked these twice daily until hatching was complete. Once hatched, these fish were sized and their survival in the absence of food was monitored. Survival to hatching was highest at the intermediate temperatures. The duration of the embryonic period ranged from 2 to over 11 d, and varied inversely with incubation temperature. The intermediate incubation temperatures resulted in the largest larvae at hatching. Duration of the yolk-sac period of larvae was independent of the temperature experienced during their embryonic periods. Our results are compared with those from other *Scophthalmus* species and with marine teleosts in general.

The Distribution and Size Composition of Five Flatfish Species in Long Island Sound Based on the Connecticut Fisheries Division Bottom-trawl Survey, 1984-1994

Kurt F. Gottschall, Mark W. Johnson, and David G. Simpson

Connecticut Department of Environmental Protection
Fisheries Division
PO Box 719, Old Lyme, CT 06371

The distribution, abundance and length composition of five flatfish species in Long Island Sound- fourspot flounder (*Paralichthys oblongus*), hogchoker (*Trinectes maculatus*), summer flounder (*Paralichthys dentatus*), windowpane flounder (*Scophthalmus aquosus*), and winter flounder (*Pseudeopleuronectes americanus*) are examined relative to season and physical features of the Sound using Connecticut Department of Environmental Protection bottom-trawl survey data collected from 1984 to 1994. Catches were plotted on maps of the Sound to display preferences for particular areas. Four species were mapped by season, while winter flounder were mapped by month and two size groups to show seasonal and spatial patterns by size. An overall length frequency was prepared for each species to show the size classes sampled by the Survey. Abundance indices were calculated and plotted by month, month and bottom type, and month and depth interval. Overall preferences for depth interval and bottom type were tested by ANOVA. Seasonal migration patterns, preferences for particular areas, and preferences for depth and bottom types within Long Island Sound are evident for all five species. For summer flounder, windowpane, and winter flounder, which are currently managed by fishery management plans, these results may be useful for the determination of essential fish habitat as required by the federal Magnuson-Stevens Act.

Aspects of the Life History of Hogchoker, *Trinectes maculatus*, in Delaware Bay Marsh Creeks

Ralph Bush and Kenneth Able

Rutgers University Marine Field Station
Institute of Marine and Coastal Sciences
800 c/o 132 Great Bay Blvd, Tuckerton, NJ 08087

During 1996 and 1997 we sampled in intertidal and subtidal habitats with weirs (n =110) and otter trawls (n =1137) to determine aspects of the life history of hogchoker, *Trinectes maculatus*. Over the salinity range sampled (0-16 ppt), hogchokers appear most dominant in creeks at intermediate salinities where they were dominated by 50-100 mm TL individuals which are approximately 1-2 years old based on a study conducted by Mansueti and Pauly (1956). In one creek system (Madhorse Creek, 10-12 ppt range), in which they were a dominant component of the fish fauna, the distribution varied with habitat type and season. They seldom occurred on the intertidal marsh surface, were slightly more abundant in shallow subtidal creeks in MLW, and most abundant in deeper 2-3 m subtidal creeks. We are currently examining aspects of reproduction and the distribution and abundance of YOY hogchokers along this salinity gradient.

Growth of Young-of-the-Year Winter Flounder, *Pseudopleuronectes americanus*, within Eelgrass, *Zostera marina*: Impact of Habitat Edge

Paul Bologna and Kenneth Able

Rutgers University Marine Field Station
Institute of Marine and Coastal Sciences
800 c/o 132 Great Bay Blvd, Tuckerton, NJ 08087

Winter flounder, *Pseudopleuronectes americanus*, recruit to shallow estuarine habitats throughout their distribution. In an attempt to assess the relative value of these habitats, growth of young-of-the-year were measured in Little Egg Harbor, NJ in May and June of 1998. Comparative growth (*i.e*., changes in standard length [mm] and weight [g]) was assessed through caging experiments in unvegetated habitat and from edge and interior portions of eelgrass, *Zostera marina*. Three caging experiments were undertaken using four replicate cages in each habitat, each containing three marked fish. Fish growth was expressed as G day^{-1} to eliminate size bias of fish differing in initial lengths and weights. Results from experimental trials indicate that *P. americanus* had greater mean G_{length} values in unvegetated habitat (0.016 day^{-1}) compared to *Z. marina* edge (0.014 day^{-1}) and interior (0.011 day^{-1}), as well as greater G_{weight} values (0.061, 0.06, and 0.047 day^{-1}; unvegetated, edge, and interior, respectively). Additionally, growth rates declined during each successive caging trial, with growth significantly reduced by the end of June ($P < 0.0001$). Temperature data collected during the experiments suggest a possible inverse relationship between growth and increasing temperature. Benthic core samples were also collected to assess the distribution of potential prey greater than 250ìm (*e.g*., amphipods, polychaetes). Preliminary results from May showed that potential prey density was greatest at *Z. marina* edge (155,911 m^{-2}), reduced in interior *Z. marina* (115,124 m^{-2}), and significantly lower from samples gathered in unvegetated sand (42, 102 m^{-2}). These data provide evidence that although potential prey density was less in unvegetated habitats, growth of *P. americanus* was greater there. This suggests that feeding by *P. americanus* may be impeded in *Z. marina*.

An Evaluation of the Relationship between Otolith Microstructure, Otolith Growth, and Somatic Growth in a Temperate Flatfish, *Scophthalmus aquosus*

Melissa J. Neuman[1], David A. Witting[2], and Kenneth W. Able[1]

[1]Rutgers University Marine Field Station
Institute of Marine and Coastal Sciences
800 c/o 132 Great Bay Blvd, Tuckerton, NJ 08087

[2]National Marine Fisheries Service
James J. Howard Marine Sciences Laboratory
74 Magruder Road, Highlands, NJ 07732

We examined the value of otolith microstructure for interpreting growth during the first year of life of windowpane, *Scophthalmus aquosus*, a northwest Atlantic bothid that exhibits bimodal (spring and fall) spawning behavior. Laboratory analysis of sagittal otoliths marked with oxytetracycline ($0.9\ g*l^{-1}$) supported the view that otolith increments are indicative of daily age for spring-spawned individuals (n=45, 15-97 mm TL) held under summer conditions. We were unable to resolve daily increments for spring-and fall-spawned individuals (n=16, 82-140 mm TL and n=27, 15-37 mm TL, respectively) held under winter conditions. When data from the three experimental groups (spring-spawned summer growth, spring-spawned overwinter growth, and fall-spawned overwinter growth) were examined separately, we detected differences in the otolith-somatic size and growth relationships between cohorts. When these data were pooled, we identified a significant decrease in the relationship between otolith size and somatic size for individuals > 57 mm TL. Our results emphasize that size-based ontogenetic state, cohort and growth conditions need to be considered when utilizing otolith sizes or inter-increment distances for back-calculating somatic sizes and growth rates.

Development of Spawning and Rearing Techniques for Southern Flounder in South Carolina

Michael R. Denson and Theodore I. J. Smith

Marine Resources Research Institute
South Carolina Department of Natural Resources
Charleston, SC 29422

The southern flounder, *Paralichthys lethostigma*, appears to be an excellent candidate for commercial culture in the southern United States. However, controlled spawning techniques have not been developed. Several strip-and tank-spawning experiments were conducted using previously spawned wild flounder held in captivity for two years. Fish were photo-thermally conditioned to spawn 3 months after the natural season. For the specific spawning trials, females with oocytes >500 µm were selected. Larval rearing experiments using commercial larval fish diet and combinations of enriched and unenriched rotifers and *Artemia* were conducted on offspring produced from these trials.

In the strip-spawning study 3 treatments were examined: 1) use of 100 µg GnRHa implants; 2) re-implantation of fish which ceased to spawn; and 3) natural ovulation. Mean egg production of implanted fish (mean size 1.48 kg) was > 376,250 eggs/female and fertility was 69.5%. These fish began ovulating within 48 hr post-hormone treatment and spawned ~3 times. Naturally ovulating fish (mean size 1.38 kg) produced 645,000 eggs/female, however fertility was only 37.6%. Mean spawning frequency (n=7) was significantly higher than for the hormone-induced fish. Re-implanted females also produced eggs (208,000 eggs/female) within 48 h, but fertility (39%) was significantly less than that recorded from the first spawn after initial implantation.

A number of tank spawnings were conducted using females > 2.0 kg in weight. In all studies, a 2:1 male to female sex ratio was maintained. The first study compared implanted (100 µg GnRHa) *vs* nonimplanted females placed in tanks with nonhormone treated males. Fertilized eggs were regularly produced from the tank containing the implanted females while only nonfertilized eggs were obtained from the tank containing the nonimplanted females. The second study used testosterone implants to examine their potential to elicit courtship and spawning behavior among nonperforming males. Courtship behavior was not noted and only nonfertilized eggs were produced. In the third study, the females from study 2 were hormonally-treated (100 µg GnRHa) and returned to the same group of males. Several groups of fertilized eggs were produced but then spawning ceased. The final study examined the potential of spawning small females (< 1.5 kg) implanted with 100 ìg GnRHa. Several small batches of fertilized eggs were produced initially but spawning ceased shortly thereafter.

Our results indicate that fertilized eggs can be produced by strip-spawning naturally ovulating females and spermiating males. GnRHa implants can hasten ovulation but duration of spawning is shorter than among naturally ovulating females. Reimplantation of spawned females can result in production of additional eggs but number of eggs and fertility are lower. Male courtship behavior appears to be the limiting factor in production of fertilized eggs from tank spawning. Use of GnRHa-implanted females has been helpful in stimulating male courtship.

A larval rearing study was designed to determine if survival and pigmentation is affected by diet combinations of rotifers and *Artemia* (enriched and unenriched) and Lansy diet. At 24ºC, five-day-old larvae (1.98 ± 0.1 mm TL) began feeding on the rotifer *Brachionus plicatilis* and completed metamorphosis by day 30. In treatment 1, larvae (6 dph) were fed rotifers (unenriched)(10/ml) days 6-15 and *Artemia* nauplii (unenriched)(3/ml) day 7 through metamorphosis. The second treatment was fed rotifers (HUFA-enriched) from 6 dph through metamorphosis and *Artemia* (HUFA-enriched) 7 dph through metamorphosis, while treatment 3 was fed rotifers (unenriched)(10/ml) days 6-15, *Artemia* (HUFA-enriched) 7 dph through metamorphosis and a commercially prepared larval diet (Lansy diet) day 13 through metamorphosis. Survival was variable and no differences were detected between treatments. Treatment 3 had significantly more normally pigmented fish than did any of the other treatments.

Comparison of Diets Among Four Co-occurring Juvenile Flatfishes near Kodiak Island, Alaska

Brenda A. Holladay

University of Alaska Fairbanks
Institute of Marine Science
PO Box 757220, Fairbanks, AK 99775

Diets of four abundant juvenile flatfishes near Kodiak Island, Alaska were evaluated with respect to size of predator, and the depth and substrate of capture. Age-0 and age-1 flathead sole, *Hippoglossides elassodon*, Pacific halibut, *Hippoglossus stenolepis*, yellowfin sole, *Pleuronectes asper*, and rock sole, *Pleuronectes bilineatus*, were collected at depths ranging from 0 to 100 m and on substrates of mud, sand, or gravel. All fishes primarily consumed small crustaceans, of which the most common taxa were mysids, crustaceans, and gammarid amphipods. The specific prey taxa consumed depended on the size of predator and the physical parameters of the capture site. There were indications that interspecific and intraspecific dietary overlap were reduced at sites where predators of different species or different sizes within a single species were captured together.

Somatic Growth and Otolith Growth in Juvenile Fringed Flounder, *Etropus crossotus*

Marcel J. M. Reichert[1], John M. Dean[1], Robert J. Feller[1], and John M. Grego[2]

[1]*University of South Carolina*
Belle W. Baruch Institute for Marine Biology and Coastal Research
Columbia, SC 29208

[2]*University of South Carolina*
Department of Statistics
Columbia, SC 29208

The fringed flounder, *Etropus crossotus*, in South Carolina has a maximum life span of 1.5 years and spawns from March through October. The long spawning period makes it difficult to determine growth rates of individuals and the population as a whole. Growth rates can only be estimated if the size and age of field-collected individuals is known with precision. A laboratory growth experiment was designed to estimate short-term growth rates of juvenile fringed flounder at various temperatures, and to investigate the relationship between otolith growth and somatic growth. Growth of the fish was determined with Alizarin-marked fish at 14, 19, 24 and 28ºC, under defined feeding conditions for 66 days. After an adaptation period of 18 days, the fish were measured and weighed at 12-day intervals. The number of daily increments formed during the experiment was not significantly different from 66, validating formation of 1 increment/day. The somatic growth increased with temperature and was highest at 24 and 29ºC. The width of increments formed during the experiment increased with increasing somatic growth. The nature of this relationship and its use for estimating growth of individuals from field collections will be discussed.

Utilization of Intertidal and Marina Habitats by Juvenile Winter Flounder, *Pseudopleuronectes americanus*

Matthew E. Mroczka[1], John K. Carlson[2], Todd A. Randall[3], and Peter E. Pellegrino[4]

[1]Cedar Island Marine Research Laboratory
PO Box 181, Clinton, CT 06413

[2]National Marine Fisheries Service
Southeast Fisheries Science Center
3500 Delwood Beach Road, Panama City, FL 32408

[3]University of Mississippi
Department of Biology
University, MS 38677

[4]Southern Connecticut State University
Department of Biology
New Haven, CT 06515

Creation of marinas involves removal of integral parts of the existing ecosystem such as salt marshes and intertidal flats which function as nursery habitat for juvenile fish. Yet, preliminary studies on marinas have suggested that they do not totally displace juvenile fish. To evaluate this suggestion, the relative abundance of juvenile winter flounder, *Pseudopleuronectes americanus*, was compared in two areas: a marina basin and an adjacent intertidal habitat. Winter flounder were sampled with a 1-meter beam trawl monthly from March through November 1990-1995. Both habitats were dominated by young-of-the-year and age 1+ fish. We found no significant difference in the relative abundance of flounder among habitats for all combined years sampled. The average density was 0.04 ± 0.06 flounder/m within the marina and 0.03± 0.04 flounder/m within the intertidal flat. We found seasonal variation in abundance with highest number caught during the summer months (June-August) and lowest during spring (March-May). The results of this study suggest that young-of-the-year winter flounder are equally abundant in both natural intertidal habitats and marina basins, indicating that both could serve as nurseries. However, more specific research is required to resolve the importance of marinas and the factors involved in the utilization of each habitat.

Winter Flounder Tagging in Western Cape Cod Bay in the Decade of the 1990s: Movements, Fidelity, and Population Size

R. Lawton, B. Kelly, J. Boardman, and V. Malkoski

Massachusetts Division of Marine Fisheries, Pocasset, MA 02559

No Abstract Available

Effects of 2, 3, 7, 8- Tetrachloroolibenzo-p-Dioxin on Winter Flounder Embryos from NY/NJ Harbor Estuary and Long Island Sound

K. Cooper

Rutgers University, Department of Biochemistry and Microbiology, New Brunswick, NJ 08901

No Abstract Available